

DISSERTATION

Gearing Up and Getting There

Improving Local Response to
Chemical Terrorism

BRIAN K. HOUGHTON

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PARDEE RAND GRADUATE SCHOOL



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Gearing Up and Getting There

Improving Local Response to Chemical Terrorism

BRIAN K. HOUGHTON

This document was submitted as a dissertation in April 2004 in partial fulfillment of the requirements of the doctoral degree in policy analysis at the Pardee RAND Graduate School. The faculty committee that supervised and approved the dissertation consisted of Bruce W. Bennett (Chair), Dick J. Hillestad, and Eric V. Larson. James L. Regens was the outside reader for the dissertation.



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Preface

This dissertation is submitted in partial satisfaction of the requirements for the degree of Doctor of Philosophy in Policy Analysis at the Pardee RAND Graduate School. The research attempts to improve response to a chemical terrorist incident by following a methodology comprising examination of the risk of chemical terrorism, the capacity and performance required to respond to such an act, cost-effective options to meet performance goals, and budgetary analysis. The findings should be of use to emergency responders and municipal policymakers who must balance their need to be prepared to prevent or to respond to an act of chemical terrorism against all other resource-demanding activities in a metropolitan area. While the dissertation focused on Los Angeles as a case study, the methodology and lessons should be useful to other communities throughout the nation, as well as a framework for making other decisions in an environment of uncertainty.

The author acknowledges the support provided by the independent research and development provisions of RAND's contracts for the operation of its Department of Defense Federally Funded Research and Development Center, the National Defense Research Institute (sponsored by the Office of the Secretary of Defense). The author also acknowledges the generous support of the National Memorial Institute for the Prevention of Terrorism (MIPT), which provided the author with time to pursue this research. The opinions and conclusions expressed are those of the author and should not be interpreted as representing those of RAND, MIPT or any other agency.

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Abstract

This dissertation identifies policies and organizational options at the local level that could save lives and/or reduce injury likely to occur from an act of chemical terrorism. The dissertation seeks out low-cost options to improve the current performance level in responding to chemical terrorism. The dissertation uses Los Angeles as a case study in this effort.

The dissertation follows a four-part framework. First, it attempts to determine the level of risk of chemical terrorism in Los Angeles and identifies an anticipated magnitude for which emergency responders and decision makers should plan. Second, the dissertation considers current capability and performance levels in chemical terrorism response and determines a performance goal for response to the planning magnitude. Third, through modeling and simulation the dissertation presents low-cost options in equipment, training, organization and doctrine that could improve the response to a chemical terrorist event. Lastly, the dissertation examines these low-cost options in terms of budget considerations in Los Angeles.

The dissertation's findings point to decentralizing counter-chemical terrorism equipment throughout the Los Angeles metropolitan area, the reformulation of certain doctrinal policies that may inadvertently slow the mitigation process, the establishment of low-cost training methods to enhance the specialized knowledge needed to respond effectively, the inclusion of doctrinal policies to accelerate the decontamination process, and the continued focus on an all-hazards approach to preparedness.

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Most of all I am grateful to three individuals. Firstly, Jonathan Schachter, who walked beside me along this whole process and read more versions of this dissertation than friendship should ever bear. I will forever be in his debt. Secondly, Ron Van Wagenen, who helped me create the computer simulation models that I used in this dissertation. His help was essential. Lastly, I am eternally grateful for my wife, Caryn, whose prayers and longsuffering has finally paid off—this dissertation is dedicated to her.

Chapter One: Introduction

"The effect [of chemical agents] is so deadly to the unprepared that we can never afford to neglect the question." -- General John J. Pershing¹

The objective of this dissertation is to identify specific policies and organizational options at the local level that could save lives and/or reduce the harm likely to occur from an act of chemical terrorism. Currently there is much anxiety over the actual and potential threat and impact of terrorism in the United States. The September 11, 2001 terrorist attacks will remain a testament to the incredible destructive power that terrorists can employ. Before, and even more so after, that singular event there have been efforts to prepare at the federal, state, and local levels for acts of terrorism, especially those involving weapons of mass destruction (WMD).²

This dissertation will focus exclusively on chemical terrorism. While there has been increased discussion about biological and radiological terrorism, especially in the wake of the anthrax-tainted letters in the fall of 2001 and the arrest of the "dirty" or radiological bomber suspect, Jose Padilla, in 2002, and the evidence of al Qaeda interest in other biological agents such as smallpox, chemical terrorism still remains a threat. The response to a chemical terrorist act is very different from that to a biological terrorist attack, in terms of who would be the first to discover the incident, who would be charged with mitigating the effects, and how quickly they must act.

Terrorists often have multiple goals to accomplish through their actions. Terrorists seek through their acts of intense violence to create an atmosphere of anxiety and fear among the population. This may be done in order to promote a political or social cause, to send a message to a target group, or as revenge for real or perceived wrongs. If this is the case, why might terrorists commit

¹ *Medical Management of Chemical Casualties Handbook*, Chemical Casualty Care Office, Medical Research Institute of Chemical Defense, September 1995.

² Weapons of mass destruction are often defined as chemical, biological, radiological, or nuclear weapons intended to cause mass casualties.

acts of chemical terrorism when more conventional terrorist attacks might bring about a similar number of casualties?³

It has been suggested that in a world environment where terrorism has proliferated, the public is becoming desensitized to relatively small acts of terrorism. As overall incidents of terrorism are decreasing, the magnitude of injuries and fatalities is increasing.⁴ This rise in fatalities and injuries reflects the increasingly violent nature of terrorists themselves⁵ as well as the need to increase lethality in order to capture the media's attention. The rise in lethality may also reflect a failure in the government's ability to provide protection. The internal and media-driven push for greater violence has led to the concern over terrorist use of chemical terrorism, which has the potential for graphic, large scale lethality and substantial psychological effects.⁶

Terrorists themselves have started to talk about using chemical weapons in their campaigns.⁷ Osama bin Ladin himself has said, "We don't consider it a crime if we tried to have nuclear, chemical, biological weapons. If I have indeed acquired these weapons, then I thank God for enabling me to do so."⁸ Recently, the United States released to the United Nations a report claiming that, "There is a 'high probability' that al-Qaida will attempt an attack with a weapon of mass destruction in the next two years."⁹ The United States has articulated through official policy and the media that it is concerned with the potential of terrorists using weapons of mass destruction, including chemical weapons. It follows that terrorists observing our publicly aired concerns might consider how to turn our fears into reality.

³ The September 11 terrorists used simple means—box cutters and pocket knives—to hijack planes and create the single largest act of terrorism with approximately 3000 deaths.

⁴ Bruce Hoffman, "Terrorism, Trends, and Prospects," in *Countering the New Terrorism*, edlan O. Lesser, et al. (Santa Monica, Calif.: RAND, 1999)

⁵ Terrorism analysts debate that with the rise in religious based terrorism there are fewer inhibitions to cause more fatalities, see Steven Simon and Danilel Benjamin, "America and the New Terrorism," *Survival*, vol.42, no.1, Spring 2000, pp.59-75 or Bruce Hoffman, *Inside Terrorism*, Columbia Univeristy Press, 1998.

⁶ Robert Bunker suggests that terrorists are seeking for "weapons of mass disruption" that might lead less to mass fatalities, but to large scale disruption and panic, see Robert J. Bunker, "Weapons of Mass Disruption and Terrorism," *Terrorism and Political Violence*, vol 12.1, Spring 2000.

⁷ Ahmed Salama Mabruk, a leader of the Egyptian Islamic Jihad, stated the group had "chemical and biological weapons" at its disposal to use against American and Israeli targets, "Islamic Jihad Threatens Chemical Warfare," AFP Newswire, April 19, 1999.

⁸ Kimberly McCloud and Matthew Osborne, *WMD Terrorism And Usama Bin Laden*, CNS Report, Monterey Institute of International Studies, March 7, 2001, <http://cns.miiis.edu/pubs/reports/binladen.htm>.

⁹ Edith M. Lederer, "U.S. Rates Chance of al-Qaida WMD Attack," Associated Press, June 10, 2003.

We have already seen incidents of chemical terrorism. In March of 1995, the Japanese apocalyptic cult, Aum Shinrikyo, delivered a simultaneous chemical attack in the subways of Tokyo using the chemical agent sarin. This attack, while poorly executed and with an impure sarin compound, killed 12 people, directly injured over a thousand, and caused psychosomatic effects in an additional four thousand. Hundreds of fire fighters and medical workers responded to the incident and many of these responders themselves were exposed to the gas.¹⁰ This incident was a clarion call to leaders worldwide that chemical terrorism was a reality, and that cities and countries needed to be better prepared to respond to future incidents.

Since the Tokyo attacks, there has been much literature generated by the federal government, practitioners, and scholars about the threat and ramifications of a chemical terrorist incident,¹¹ and on methods to respond to a chemical incident.¹² However, there is a dearth of material on cost-effective approaches to preparation or response. Responders in each metropolitan area must select the methods they feel would be best for their environment, but with little analysis to assist them in their decision-making. This has resulted in each city, county, or other jurisdictional area choosing equipment, methods, and policies that often differ significantly from those even of neighboring communities that in times of emergency may be required to assist each other.¹³

This dissertation strives to assist communities in their preparation to prepare for or respond to a future chemical terrorist attack. While the dissertation will not instruct on exactly how many additional fire apparatus, hospital showers, or other such low-order items a community needs, it will help inform

¹⁰ Approximately 10 percent of the firefighters and 23 percent of the hospital staff exhibited symptoms of sarin poisoning, see Sadayoshi Ohbu, et al., "Sarin Poisoning on Tokyo Subway," <http://www.sma.org/smj/97june3.htm>; and George Buck, *Preparing for Terrorism: An Emergency Services Guide*, Delmar Publishers, 1998.

¹¹ For example, see the Henry L. Stimson report *Ataxia*, the annual reports of the Advisory Panel to Assess Domestic Response Capabilities for Terrorism Involving Weapons of Mass Destruction, the report of the National Commission on Terrorism, Richard Falkenrath's *America's Achilles Heel*, etc.

¹² For example, see the Soldier Biological Chemical Command's reports *Guidelines for Mass Casualty Decontamination During a Terrorist Chemical Agent Incident*, *Guidelines for Incident Commander's Use of Firefighter Protective Ensemble (FFPE) with Self-Contained Breathing Apparatus (SCBA) for Rescue Operations During a Terrorist Chemical Agent Incident*, and *Guidelines for Cold Weather Mass Decontamination During a Terrorist Chemical Agent Incident*.

¹³ Neighboring communities typically have signed agreements to provide mutual aid when the response to an incident requires more equipment and personnel than the local responding agency has available.

the metropolitan policymakers of important considerations to take when improving preparedness for a chemical terrorist threat.

Scope

As stated previously, the dissertation will focus on chemical terrorism and not on biological or other types of terrorist acts. There is an adage that "all terrorism is local,"¹⁴ thus this dissertation examines the policies, levels of preparedness, and needs at the local level rather than at the state or federal level. However, assets from the state and federal level that can assist the local preparedness or response to terrorism will be examined. The dissertation will particularly examine the on-scene response and the initial emergency hospital care of chemical terrorism victims, but will not study the possible long-term medical or psychological needs of the victims. Although this dissertation acknowledges that it is better to prevent a terrorist attack, the main focus of the study will be on preparedness and response to a chemical terrorist attack. Additionally, the examination of the local response does not include the pre-deployment of local, state or federal units at special events.¹⁵

Los Angeles

As a case study, this dissertation will examine the state of preparedness and options to improve response to chemical terrorism in Los Angeles, California. Los Angeles, as the second largest city in the United States, has already spent considerable time and budget considering and preparing for an incident of chemical terrorism. The dissertation's author also had the opportunity to work for several years with the leaders of the Los Angeles emergency responding community, which has led to access to much of the data and information needed for this dissertation.

¹⁴ Second Annual Report to the President and the Congress of the Advisory Panel to Assess Domestic Response Capabilities for Terrorism Involving Weapons of Mass Destruction, *Towards a National Strategy for Combating Terrorism*, December 2000, p. G-18.

¹⁵ This dissertation strives to provide policy recommendations for improved preparedness for the normal day-to-day operations in counter-terrorism, rather than focus on infrequent special events. Thus the pre-deployment of resources at a special event represents the exception rather than the rule to everyday preparedness.

Los Angeles¹⁶ was one of the first cities to receive federal funding for WMD terrorism training and equipment, which was primarily focused on chemical terrorism, through the Nunn-Lugar-Domenici Act of 1996, and has been judged since by many experts as one of the most capable American cities to respond to a WMD terrorist incident.¹⁷ Los Angeles' efforts and achievements toward preparedness have been featured in two of the Gilmore Commission's annual reports as models for other cities to consider.¹⁸

While it has made great strides toward preparation, Los Angeles still is striving to improve its readiness and its ability to prevent a large-scale terrorist incident taking place within the metropolitan area. By the end of 2002 Los Angeles had already received approximately \$30 million dollars from the federal government to prepare for a WMD terrorist event, and has and will continue to spend considerable amounts of money from local funds. With limited local, state and federal funding available to Los Angeles to prepare, it is beneficial to examine how best to utilize those funds. This dissertation demonstrates a cost effectiveness approach for decision-makers, who must make the difficult decisions of where to channel their limited resources: towards effective terrorism prevention and preparedness and towards other needed services for the community. This approach can be driven by required performance capabilities or by budgets, and this dissertation will examine the results of both approaches. While this dissertation focuses on chemical terrorism, the same approach could be used in other cases when budget allocation decisions need to be made in an environment of high uncertainty.

¹⁶ In the dissertation Los Angeles will be defined as the city of Los Angeles and the other 87 cities within the county of Los Angeles. Unless specified as "the city of Los Angeles," the term Los Angeles will refer to the metropolitan area within the county, rather than populated areas outside of the county that are often considered as "greater Los Angeles." Many of the policy options in this dissertation will be for Los Angeles County executives, Sheriff, County Fire Chief, and Department of Health Services who have jurisdiction throughout the county and not the city of Los Angeles itself.

¹⁷ Dr. Lew Stringer, medical director of the Special Operations Response Team, quoted in CNN.com's in-depth coverage on WMD prepared cities said, "In my opinion, the two cities that could handle [a WMD terrorist incident] alone, without asking or needing immediate outside resources, would be New York and Los Angeles." Mike Fish, "How Prepared is Your City?" CNN.com, January 17, 2002, <http://www.cnn.com/SPECIALS/2002/prepared.cities/stories/lead.story.html>.

¹⁸ The Gilmore Commission is the Congressionally mandated commission named after its chair, Gov. James Gilmore of Virginia, but the official name is the Advisory Panel to Assess Domestic Response Capabilities for Terrorism Involving Weapons of Mass Destruction.

Organization of the Dissertation

This dissertation is not intended to give decision-makers an exact answer, but to better inform them how to think through this difficult issue, and is organized in the following manner:

- Chapter Two will detail the approach and analytical framework that will be explored throughout the dissertation to provide an illustration for decision-makers of how to frame the issue.
- Chapter Three will examine the threat of chemical terrorism in general and in Los Angeles in particular. The chapter will also define and look at the risk of chemical terrorism and determine the level of risk that decision-makers should consider as a basis for their resource allocation.
- Chapter Four will look at the current performance capabilities existing in Los Angeles to prevent, prepare for or respond to a chemical terrorist event. The chapter will also examine a model that simulates the response capability in Los Angeles.
- Chapter Five will examine programming options that offer to make the most of cost-effective elements in local prevention and response capabilities. The chapter will examine the types of capabilities and the levels to be used.
- Chapter Six will evaluate budget and other resources available to apply towards countering chemical terrorism and how budgets may drive response capabilities.
- Chapter seven will conclude the dissertation with more specific policy recommendations.

Chapter Two: Background and Framework for Analysis

This chapter provides background and a framework to respond to chemical terrorism across the nation and specifically in Los Angeles. The framework addresses how to more effectively allocate resources to maintain and improve the means by which agencies respond to such an attack. What is needed is a pragmatic approach for decision makers to evaluate the capabilities required to respond to chemical terrorism in the shadow of other public concerns and needs, recognizing that localities are not starting from scratch, and have already an endowment of capabilities in this area. The analysis from this dissertation is to help localities determine at the margin what changes would be best to improve performance while striving to limit the costs.

As the nation reacted to the Murrah Federal Building bombing in Oklahoma City and news of the release of the chemical agent sarin in the Tokyo subway, both occurring in the spring of 1995, there was a feeling of urgency to prepare for the potential of mass casualty terrorism, especially that using chemicals, such as those used in Japan.¹⁹ Prior to 1995 the level of local preparedness to respond to a chemical terrorist attack typically was no greater than the basic training of the local hazardous material unit—whose main focus was the mitigation of an industrial chemical spill and the decontamination of its members as well as a handful of potential victims. Hospitals too, prior to 1995, had little or no training for responding to the anticipated mass casualties of a chemical incident. For example, the Joint Commission on Accreditation of Healthcare Organizations (JCAHO), which sets national standards for hospital care, mandates hospitals to have the ability to decontaminate only a single person.²⁰

¹⁹ See Armando Bevelacqua and Richard Stilp, *Terrorism Handbook for Operational Responders*, Delmar Publishers, 1998, pp 1-2.

²⁰ JAHCO standard for emergency management EC 1.4 includes decontamination, but does not specify a fixed facility such as a shower, rather details hospitals to have the capability to decontaminated one person, which could easily be a hose to spray down patients when needed.

Senators Nunn, Lugar and Domenici recognized the need in 1995 to improve the capability of the nation at the local level to respond to mass casualty terrorism caused by WMD attacks and co-sponsored the Defense Against Weapons of Mass Destruction Act of 1996.²¹ This legislation gave the Department of Defense the mission to train responders in the 120 largest cities (by population) across the nation in detection, monitoring, protecting personnel and the public from and decontamination of chemical and biological agents. The Nunn-Lugar-Domenici (NLD) Act, as it was popularly called, provided \$300,000 for equipment, training, and exercises to each of the 120 cities to achieve these goals. In 2000, President Clinton transferred the responsibility for the NLD training mission from the Department of Defense to the Department of Justice, in the jurisdiction of the Office of Justice Programs' Office of Domestic Preparedness (ODP). In 2003 ODP became a part of the new Department of Homeland Security.

The Department of Health and Human Services created the Metropolitan Medical Response System (MMRS) in 1996, which was to form a coordinated system between fire, law enforcement, emergency medical services, hospitals and public health to better respond to chemical or biological terrorist attacks. The MMRS started with two cities and has grown to 122 across the country. While NLD training focused more on the traditional first responder (i.e., law enforcement and firefighters), the MMRS focused on the medical community—often focusing on preparing a specialized group to respond medically to either a chemical or biological attack.

The Los Angeles metropolitan area has benefited in terms of equipment and training from both of these federal programs. Los Angeles was the second city in the nation (New York City was the first) to start receiving training as a result of the NLD Act. The training focused on chemical and biological attacks, and was intended to train trainers who could then pass the knowledge to responders throughout the area. The training culminated in a massive, weeklong, chemical terrorism exercise called "Westwind" involving city, county, and federal responders.

²¹ Public Law 104-201, Title XIV, National Defense Authorization Act of 1996.

Los Angeles created an MMRS, and later was selected to receive funding for the Western National Medical Response Team—one of four NMRTs in the nation that have reserve medical personnel with increased training for chemical and biological response and additional pharmaceutical stockpiles. The NMRT is a federal funded asset comprised of approximately 54 local emergency medical personnel to assist in needed to provide medical expertise in either a biological or chemical attack.

In addition to the standard \$300,000 granted by the NLD Act, Los Angeles County applied for and received a \$250,000 grant from the Department of Justice for enhanced training and the development of a suite of videos to reinforce the training principles. The county has received an additional \$500,000 from the federal government for the purchase of counter chemical and biological terrorism equipment. An additional \$24.6 million came from the U.S. Centers for Disease Control and Prevention (CDC) for a new laboratory and improvements in public health, and the Health Services and Resource Administration granted \$3.6 million for improvements in hospitals to counter chemical and biological terrorism. While the federal government has given Los Angeles approximately \$34 million, Los Angeles has spent over \$120 million of its own money in preparing to prevent or respond to terrorism.²²

The Government Accounting Office (GAO) has indicated in a number of reports their concern that the current funding for chemical terrorism preparedness²³ has been done in an ad hoc fashion.²⁴ This was also echoed by the Gilmore commission's report.²⁵ In an effort to improve the allocation process, the Office of Domestic Preparedness now requires states (as opposed to metropolitan areas) to submit a risk assessment before funding can be sent to the state for training and equipment.

²² Los Angeles' efforts include prevention and respond to all forms of terrorism, not just chemical.

²³ The GAO reports often describe the chemical and biological terrorism together, rather separating them into two distinctive types of terrorism.

²⁴ This is shown in reports from GAO such as , *Combating Terrorism: Observations on Federal Spending to Combat Terrorism* (GAO/T-NSIAD/GGD-99-107, Mar. 11, 1999), *Combating Terrorism: Threat and Risk Assessments Can Help Prioritize and Target Program Investments* (GAO/NSIAD-98-74, Apr. 9, 1998), *Combating Terrorism; Spending on Governmentwide Programs Requires Better Management and Coordination* (GAO/NSIAD-98-39, , Dec. 1, 1997), as well as Amy Smithson's *Ataxia*, Henry Stimpson Center, 2000.

²⁵ 2nd Gilmore commission report, December 2000.

However, local metropolitan areas were often ignored in their state's risk assessment and subsequent funding distribution methodology.²⁶ Regardless, local cities and counties ultimately will face the question of how best to allocate resources towards chemical terrorism response.

This is reflected in Los Angeles. The allocation of resources in Los Angeles has been accomplished to meet broadly defined needs, but has not been subjected to a rigorous examination to determine if these funds are being allocated to the most cost-effective programs or equipment. This is not an indictment of Los Angeles, or of any of the other metropolitan areas that have faced the same problem. Rather, it is merely the result of a lack of personnel, time, experience and an adequate methodology to accomplish this important task.

Local, state and federal decision makers are faced with risks, competing priorities and funding decisions on a continual basis, among which difficult trade off decisions must be made. In light of the current concern about terrorism, especially that of chemical or biological terrorism, decision makers must consider the ramifications of a potential terrorist attack along with those of traditional day-to-day issues such as crime, medical services, education and constrained budgets. How decision makers allocate resources is determined based on levels of perceived need in each of these important areas, unless a better approach is utilized to give decision makers more insight than mere perception. The key question for decision makers is what changes can be made at the margin that can have the most cost-effectively improve overall performance (i.e., harm reduction)?

Alternative Approaches to Resource Allocation Justification

There exist several approaches to determine or justify the amount of resources allocated to various risks. Whether decision makers use scenarios, or risk management tools, they are attempting

²⁶ Numerous interviews with key counter-terrorism practitioners at the local level in Los Angeles, San Jose, Washington state, and Northern Virginia all indicated that they were not included in their state assessment program.

to make a better informed resource allocation process. The following sections will portray several common methodologies used to determine or justify the resources allocated to reducing risk.

Before going further, it is important to define the terms threat, risk, threat assessment and risk assessment. For the purposes of this dissertation, the following definitions are used, based on a report submitted to the Department of Transportation concerning risks management and hazardous materials:²⁷

Threat- the combination of the intent and capabilities of an adversary to cause harm.

Threat assessment- a systematic approach to organize and analyze information on the intent and capabilities of an adversary to cause harm.

Risk – the combination of the likelihood and the consequence of a specified hazard being realized (i.e. Risk = likelihood x consequence).

Risk assessment – the systematic approach to organize and analyze information about potentially hazardous activities; this generally includes problem formulation, hazard assessment, exposure analysis, and risk characterization.

Scenario Approaches

In the last few years, worst-case scenarios have dominated the threat and risk assessment realm, leading decision makers to believe unprecedented resources would be needed to successfully address potential chemical and biological terrorist attacks. Counter-terrorism expert Brian Jenkins, in describing policy approaches to a high consequence/low probability event indicates that some policy makers feel that, "this event is so bad we cannot let it happen even once" or, alternatively, "posterity will judge us if we do not do anything about it."²⁸ Traditionally, the threat of a terrorist attack has been based on examining a terrorist group's (or multiple groups') intents and capabilities.²⁹ In today's

²⁷ ICF Consulting, *Risk Management Framework For Hazardous Materials Transportation*, Report submitted to U.S. Department of Transportation Research and Special Programs Administration, Nov 1, 2000.

²⁸ Interview with Brian Jenkins, 4 February 1999.

²⁹ See Ian Lesser, et al. *Countering the New Terrorism*, RAND, 2000 for a discussion of past threat assessments.

environment, where the group may be unknown,³⁰ it is difficult to know what its intentions or capabilities may be, so analysts often look at vulnerabilities instead, often focusing on worst-case scenarios. This has put tremendous pressure on decision makers because of the gravity of the potential consequences of chemical or biological terrorist attacks.

Amy Smithson notes in her report, *Ataxia*, when discussions are "dominated by scary what-if scenarios almost to the exclusion of technical and historical analysis, poor public policy results."³¹ Worst-case scenarios can give unrealistic expectations of the magnitude of a potential attack and can lead to either too many resources going towards this problem, or decision makers giving in to the impression that this problem is too big for them to tackle. It often seems that a community's vulnerabilities, in the absence of an identified threat, are endless when considering what a mythical terrorist group with unlimited resources might target. However, terrorists do not have unlimited resources, and there are other more effective methods besides analysts examining worst-case scenarios.

The Israeli security analyst, Yehezkel Dror, suggests a different method than "worst-case scenarios" for mapping out uncertainties. While the exact probability of the high consequence incident may be unknown, the possibilities leading to such an event often can be mapped out with greater confidence and more information can be brought to inform decision-making.³² However the military analyst Charles Murray cautions that the cost of acquiring more information on uncertainties can consume valuable resources, which raises a cost-to-benefit issue on the information collection process.³³

³⁰ For example, Aum Shinrikyo in Japan was relatively unknown to Japanese law enforcement, and not in the scope of US intelligence. Timothy McVeigh was also unknown to federal law enforcement until the bombing of the federal building in Oklahoma City.

³¹ Amy Smithson, *Ataxia*, Henry Stimpson Center, 2000.

³² Yehezkel Dror, "Uncertainty: coping with it and with Political Feasibility" in: Hugh J. Miser and Edward S. Quade, ed., *Handbook of Systems Analysis: Craft issues and Procedural Choices*, NY: North Holland, 1988, pp. 247-281.

³³ Charles H. Murray, ed. *Executive Decision Making*, U.S. Naval War College, 1 February 2002.
<http://www.nwc.navy.mil/nsdm/nsdmedm2.htm>

Current Approaches to Resource Allocation

Current approaches to resource allocation often include educated guesses, status quo spending, increased status quo spending (incremental), and the shot gun approach. While these methods do push some funding towards the problem, there is no assurance that an adequate amount of funding is going towards the most important or needed capabilities.

In the absence of analysis, most decision makers are forced to make educated guesses—relying on “gut instincts”—to assist in the allocation of resources. Decision makers may have an idea of what the problem may be, and believe they have a vision of what is needed to confront the problem, but ultimately the decision is little more than a guess.³⁴

Decision makers can also provide the same amount of funding toward law enforcement, firefighting, hazardous materials response, emergency management and public health in a status quo method. Psychologist Daniel Kahneman describes decision makers, when faced with uncertainty, often reference their decisions based on their past experience with the status quo, thus they have a “status quo bias” that tends to continue to reinforce the status quo actions.³⁵ Decision makers can also increase the status quo funding in the belief that incremental increases to the present level will augment needed capabilities. However, in the absence of analysis, there is little reason to believe that the status quo provides resources effectively to prepare sufficiently to respond to a chemical attack. Increasing the funding to ineffective programs will not improve the situation.

The shotgun approach provides funding in a wholesale fashion to numerous new and existing programs in the hope that they will improve capabilities. This method is evident at the federal level, and is reflected at the state and local levels as well. Without an examination of cost-effectiveness or risk assessment in this approach, funds go to multiple programs that may or may not lead to an improved capability, and as Philip Schaenman comments, shotgun approaches may lead a community to

³⁴ Even relying on outside experts to advise them on the problem, who do not have statistical evidence, is nothing more than relying on the educated guesses of others.

bankrupt their budget.³⁶ Each of these common approaches are nothing more than hedging—realizing that something is needed to counterbalance the risk, but unsure of cost-effective approaches of resource allocation.

Decision makers feel that they need to do something; even if this means not actually improving the capabilities of the responders, but rather merely assuring the public that efforts are underway to protect them. The perception of the public is important, since the extra funds needed to go towards countering chemical terrorism will require either increases in revenues collected or a reallocation of funds from other public services (i.e., education, health care, transportation, etc.). In the post-September 11th environment, the public is concerned about terrorism and wants to know that their communities are safe, and their leaders are striving to improve their ability to counter this problem. However, in time, if no other terrorist event takes place, the public eventually may become more concerned with other government programs.

The risk that decision makers face as they try to allocate funds towards an unknown problem, such as a future chemical terrorist attack, is that they may devote too little or too much towards the problem. If worst-case scenarios are the basis for their analysis, local and state governments may allocate too much of their budget towards the problem. Yet if the decision makers do not try to conduct analysis to estimate appropriate levels of funding, they may unintentionally devote too little of their budgets to this issue. Either way the public is not well served as the budget may be squandered on useless security or their security itself is lacking.

When considering an event with high consequences, the magnitude of the event might justify incurring some type of cost to mitigate the threat, reduce the level of risk, or improve response. In

³⁵ Jack S. Levy, "Daniel Kahneman: Judgment, Decision, and Rationality," The American Political Science Association Online. <http://www.apsanet.org/mtgs/kahneman.cfm>. This action of maintaining the status quo is a form of risk aversion.

³⁶ Philip Schaenman, "Preparedness For Consequences of Terrorism," *Small Community Quarterly*, February 2002. <http://www.natat.org/ncsc/pubs/newsletter/Feb2002/Article2.html>

examining high consequence/low probability events, even if using a simple expected value approach,³⁷ the sheer size of the consequence, even with a low probability, will justify some allocation of resources towards the problem. Expected value assumes risk neutrality, and that is one of its strengths and weaknesses. It is a strength in that it allows analysts to simply rank order options. Yet, most people, and communities, are risk adverse, and are willing to go to greater an effort to avoid risk, if possible, than what is indicated in a neutral expected value analysis.

Risk Management

An allocation determination method by risk management professionals called "consequence analysis" examines the magnitude of an event, and its probability, and determines the cost of losing the assets (property, human life, etc.).³⁸ While expected value assumes risk neutrality, consequence analysis factors in risk aversion. Decision makers need to decide the cost of making do without that asset, and/or the cost of lives lost. A high consequence event, even if the probability of such an event is extremely low, would necessitate steps to prevent the event from occurring. Priorities should be determined based on not only probability of occurrence but also the consequence. Cities may be able to live with the high probability but low consequence of lesser crimes such as littering or graffiti, but should contemplate the high consequence, but low probability of terrorism.

Richard Falkenrath promotes, instead of the reliance on "experts," a risk management approach, that is "assessing terrorism in terms of probabilities and consequences, abstract attributes that all problems possess in one way or another, and that can be usefully compared" by policy and decision makers.³⁹ Falkenrath sees terrorism not as a unique risk, but just one additional risk that society must face. What does make terrorism more powerful than other risks, however is the psychological aspect of terrorism that becomes a "force multiplier" of the incident itself. Thus terrorist

³⁷ The expected value $E(V)$ is determined by the following equation:

$$E(V) = P(\text{Success})(\text{SuccessPayoff}) + P(\text{Failure})(\text{FailurePayoff}) .$$

³⁸ Mary Lynn Garcia, "Truth & Consequence: Applying consequence analysis to prioritize elements of risk, Security Management, No. 6, Vol. 44, June 1, 2000.

³⁹ Richard A. Falkenrath, "Analytic Models and Policy Prescriptions: Understanding Recent Innovation in U.S. Counterterrorism," BCSIA Discussion Paper 2000-31, ESDP Discussion Paper ESDP-2000-03, John F. Kennedy School of Government, Harvard University, October 2000

acts "cause greater damage to societies than the statistics suggest." ⁴⁰ While casualties and damage to structures may be easy to quantify, the emotional and psychological damage, or the loss in confidence the public may have in the government's ability to protect them are less quantifiable.

While these two approaches help decision makers see terrorism as a risk that needs to be addressed using an all-hazard approach, they do not help specify the funding amount to put towards the risk. Even Falkenrath himself states that risk management can "fail spectacularly when the possible event has occurred only rarely or never at all."⁴¹ Treating terrorism as another risk faced by a public can help lead to a dual-use response—ensuring that the capability to respond to terrorism also can provide for the response to other risks (crime, chemical spills, etc.). But to base resource allocation on a method that does not have a firm understanding of the magnitude of the consequence or the probability of the risk does not help knowing if an appropriate level of capability has been reached.

Modeling and Simulation Approaches

Often decision makers have turned to modeling and simulation to provide insights in determining the appropriate levels of resource allocation. Modeling and simulation have been used for years in the emergency response and national security communities. The two following examples of using modeling and simulation come from RAND.

Every city must make the decision of how many fire stations to build, where to locate them, and how to staff them. There is, of course, variation in the number of emergencies a fire company must respond to during a day, week, or year, but it is assumed that their services will be needed with a reasonable frequency. Response times to an emergency and the number of expected emergencies, coupled with the resources needed to maintain the fire station and fire companies, are the dominant factors in determining how many fire companies and stations to have. In the early 1970s, RAND assisted the New York Fire Department (FDNY) in analyzing the allocation of fire resources and the

⁴⁰ Ibid, p. 21.

⁴¹ Ibid, p. 28.

deployment of engine companies to alarms.⁴² FDNY's rate of alarms had grown over three times in number in little over a decade and the department was being stretched thin in its ability to respond. RAND used a simulation model to explore a number of alternative policy options, saving the department time and money.

Through the use of a computer simulation model, RAND was able to compare a number of new policies affecting response times of subsequent fire companies arriving at a scene. Through RAND's computer simulation model, they were able to test the policies without the high cost of live exercise or real world changes.⁴³ RAND's FNDY simulation modeling was the beginning of geographic modeling to allocate resources, and now a number of commercial software packages like Fire Operations Suite © or RHAVE (Risk, Hazard and Value Evaluation) are available that assist fire departments to locate their resources throughout cities so as to increase efficiency and ensure faster response time. This approach is beneficial in determining where to locate stations and fire companies across an area so that responses to routine events (fires and small medical emergencies). However it does not assist in the assessment of the likelihood of a larger event, other than placing emergency personnel to arrive to the scene of the large event in a timely fashion.

Eric Larson and Glenn Kent of RAND developed an approach to determining the optimum allocation of resources in a layered defense, in this case, a layered missile defense.⁴⁴ While their approach does not assist in the determination of the likelihood of an attack (the model actually assumes that an attack does take place), the model can help decision makers determine the best resource allocation of defense mechanisms (defensive missile systems) based on the defensive capabilities. The approach specified a desired probability (e.g. ninety percent) that no attacking missiles would survive to strike their targets after passing through the various layers of defense, and

⁴² Grace Carter, Edward Ignall, and Warren Walker, "A Simulation Model of the New York City Fire Department: Its Use in Deployment Analysis," RAND, P-5110-1, July 1975.

⁴³ Ibid.

⁴⁴ Eric V. Larson & Glenn A. Kent, *A New Methodology for Assessing Multilayer Missile Defense Options*, RAND, Santa Monica, CA, MR-390-AF, 1994.

then created a framework to determine the best allocation of missile defense resources at least cost for achieving this goal.

The Larson & Kent method takes advantage of a parametric approach in that it easily allows for changes in effectiveness, up or down, in testing the model. Their framework used a simple worksheet model based on specified estimates of effectiveness of both the attacking missiles and the defense layers. Just as layered defenses can provide greater protection against missiles, so too has the options for homeland security been characterized as a layered defense solution.⁴⁵

This dissertation too will follow a simple methodology to improve the allocation of limited resources at least cost in order to better respond to a chemical terrorist attack with a pre-determined, specified level of damage—lives lost and injuries sustained.⁴⁶ This is done based on the assumption that it is impossible to stop all terrorist attacks, or stop all forms of damage, but that there should be a certain minimum level of effectiveness that can be achieved

Rather than no analysis (i.e., guessing), or a faulty approach such as that of worst-case scenarios, decision makers can make informed decisions if they follow an approach taking in consideration risk (including event probability), capabilities, cost-effectiveness and budget, as well as understanding the robustness of various options in the face of uncertainties.

A Pragmatic Approach to Countering Chemical Terrorism

The framework presented in this dissertation is to assist decision makers in conducting a pragmatic approach towards this problem. The approach is to confront the whole problem of chemical terrorism rather than focus solely on one area (i.e., to look at response on-scene of the attack and at hospitals, rather than focus solely on hospital response). Taking a layered defense approach, rather

⁴⁵ Michael B. Donley, "Reading Strategy Between the Lines," *Journal of Homeland Security*, August 2002. Internet: <http://www.homelanddefense.org>. While some of the defensive layers include diplomatic, military and foreign intelligence options, this dissertation will focus on layers of defense on the local level.

than only a reactive approach that rests on a strong response capability, can provide a better method to confront chemical terrorism. While more funding traditionally goes towards response, a layered approach that places funding, priorities, personnel, equipment, and training in areas of prevention, and response would limit the number of incidents an area would face as well as provide a better response if needed.

The approach taken in this dissertation is not one of precision. As in many of the current approaches indicated above, and will be explored in Chapter Three, precision in this area difficult since there is little data, and educated guesses may be required for elements of the framework. We do not know exactly what the probability is of a chemical terrorist attack occurring in a city like Los Angeles, nor do we know what the magnitude might be if one does occur. But we can take a parametric approach, that is, make an educated assessment of the probability of a chemical terrorist attack, probable magnitudes, capability of the terrorists, etc. and then examine what the results would be if the parameters were somewhat higher or somewhat lower to determine the ramifications of those increases or decreases. The approach to be followed in this dissertation, which will be further outlined below, builds upon from analysis performed for the U.S. Army by two RAND policy analysts, Eric Larson and Jed Peters, and described in the monograph *Preparing the U.S. Army for Homeland Security: Concepts, Issues, and Options*.⁴⁷

Fundamentally the approach here seeks to answer four questions:

- What types and magnitudes of threat are we planning against, and what risks of chemical terrorism do we face?

⁴⁶ While business and property may be lost in a terrorist attack, this dissertation will focus on the loss of life and injury.

⁴⁷ I assisted in the Larson and Peters project by providing a paper for the study, as well as gathering data to be used in the book. The idea for this dissertation grew out of my participation in this study. The approach of their project was to examine homeland security at-large by analyzing specifically how the Army could participate in this new role. This dissertation seeks to use the same framework, at the local level, and limit it to countering chemical terrorism. See Eric Larson and John Peters, *Preparing the U.S. Army for Homeland Security: Concepts, Issues, and Options*, RAND, MR-1251-A, 2001.

- What counter chemical terrorism capabilities are needed to meet the specified planning magnitude?
- What are the most cost-effective program options for providing capabilities with the needed performance levels in incidents of specified planning magnitudes?
- What resources should be available for counter chemical terrorism programs?⁴⁸

By answering these questions decision makers will be able to better know for what resources to allocate funds. Larson and Peters used a notional nomogram⁴⁹ to depict the subject area of these questions to assess homeland security measures for the Army (See Figure 2.1 below). This dissertation postulates that decision makers can follow a similar framework—analyzing levels of threat and magnitude of potential incidents to determine capabilities of response and then find cost-effective approaches and ultimately determine budget levels—to assist in counter chemical terrorism preparedness. Each of these sub elements in this framework builds on each other to complete the necessary analysis for determining how to allocate resources to confront the problem best in order to save lives and reduce damage.

⁴⁸ Adapted from Larson & Peters, 2001.

⁴⁹ A nomogram is an engineering tool to assist in following details from one graph to another.

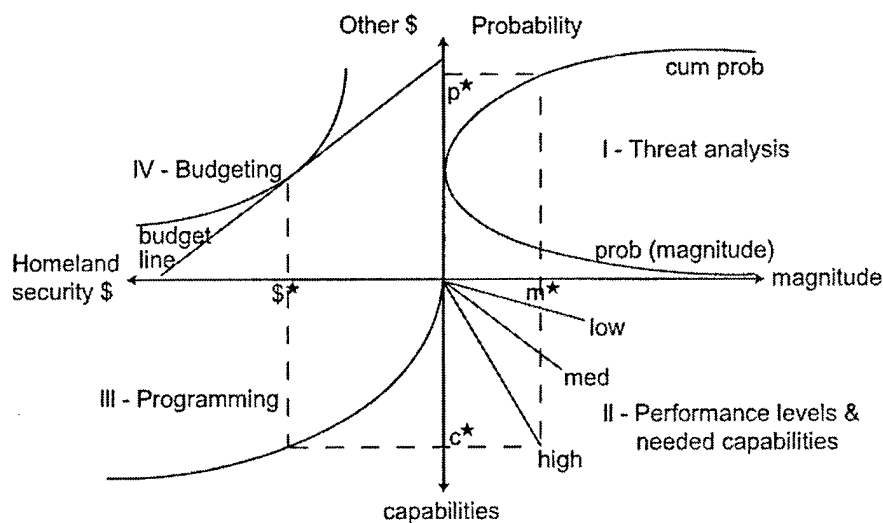


Figure 2.1 Nomogram for Assessing Counter Chemical Terrorism Options⁵⁰

The above nomogram gives the impression that a point solution is obtainable, but this was not the case in the original work by Larson and Peters, nor is it the goal of this dissertation. More important than the representation of the individual quadrants, is the analysis performed in each of these four areas. The first framework area, or domain, of this dissertation represents a planning framework requiring a study of threat and risk assessment to assist in obtaining an estimate of the magnitude of a chemical terrorist attack for which the local area should prepare itself. In the second area decision makers determine what levels of capability they wish to use to respond to incidents of chemical terrorism. They may wish to use low, medium or high performance levels to respond to the chemical attack, but realize that the greater the performance level to meet the chosen magnitude will result in an increase in needed capabilities. The third area requires analysis on cost-effectiveness for the necessary programs to respond to chemical terrorism. In the last area, a trade-off is made between the cost of the desired counter chemical terrorism programs and all other costs associated with the metropolitan area. The sections that follow will elaborate the functions of each of these four areas.

⁵⁰ Larson and Peters, 2001.

Threat & Risk Analysis

In the first area of the planning framework the question to be asked is what is the relative probability of alternative terrorist incident outcomes? Having an understanding of the threat to be faced or the level of risk, by performing a threat and risk assessment of a chemical terrorist attack, leads to an estimate of the potential magnitude of the chemical terrorist attack that an area like Los Angeles may face. By then estimating the magnitude, metropolitan leaders, as well as emergency responders, have a benchmark by which they can plan their response, preparation, or methods to prevent such attacks. The definition of magnitude that will be used in this dissertation is the number of casualties who are directly exposed to the chemical agent. These contaminated individuals may be exposed to the chemical in gas or liquid form, but the exposure will necessitate some sort of decontamination and/or treatment in order to prevent injury or possible death. The GAO, as mentioned above, has devoted five reports since 1998 on the need for risk and threat assessment to inform the allocation of resources to countering terrorism, especially that involving chemical or biological weapons.⁵¹

In the first area of the planning framework the probability of a chemical terrorist attack and its possible magnitude in terms of casualties is examined. In past episodes of terrorism, as well as most threats, the likelihood of an attack is inversely related to its magnitude. This is almost certainly the case in chemical terrorism, since for technical and other reasons it is easier to conduct a small-scale chemical attack than a large-scale attack. Thus, the probability decreases as the consequence increases.

Using the framework detailed in this dissertation, decision makers would need to analyze the threat and of chemical terrorism in order to try to develop a cumulative probability distribution of future events of concern, and select a reasonably high cumulative probability (e.g., 90 percent) that lets the

decision makers say “We are making preparations to deal with 90 percent of the attacks that we think we might face.” This, as will be discussed in the following chapter, is difficult due to the lack of data on chemical terrorism—few actual events have taken place to create a benchmark for probability. If the probability of a future event is difficult to determine, decision makers can choose a planning magnitude to base their analysis that gives them a comfort level in being able to hedge against a range of attacks.⁵² For this dissertation, the planning magnitude that will be used is one thousand (1,000) exposed victims—the rationale for this decision will be detailed in the following chapter. With the planning magnitude selected, we can then move to the second area of the planning framework.

Performance Levels

In the second area of the framework the main question to be answered is what capabilities are needed at specific magnitudes? The magnitude that is to be met in this quadrant has already been determined through either a threat and risk assessment or by choosing a planning magnitude in the previous domain.

In this area of analysis, capabilities to respond to the planning magnitude are examined. There are an infinite number of potential capabilities levels that could be used to meet the specific magnitude, but this dissertation will look at a low, medium and high capability approach.⁵³ In responding to chemical terrorism, the most important factor is how quickly the defenders can respond. Generally, the slower the response, the higher is the likelihood of death or injury of the victims. The smaller the

⁵¹ Government Accounting Office reports *Combating Terrorism: Linking Threats to Strategies and Resources*. T-NSIAD-00-218, July 26, 2000; *Combating Terrorism: Need for Comprehensive Threat and Risk Assessments of Chemical and Biological Attacks*. NSIAD-99-163, September 7, 1999; *Homeland Security: Key Elements of a Risk Management Approach*. GAO-02-150T, October 12, 2001; *Homeland Security: A Risk Management Approach Can Guide Preparedness Efforts*. GAO-02-208T, October 31, 2001; and *Combating Terrorism: Threat and Risk Assessments Can Help Prioritize and Target Program Investments*. NSIAD-98-74, April 9, 1998.

⁵² The decision can also be made the other direction by first choosing the magnitude and seeing what cumulative probability that represents. This is an imprecise endeavor since it is near impossible to determine the probability of an attack at almost any magnitude, however as the magnitude of the consequence rises the probability falls rapidly. Policymakers need to pick a cumulative probability for which they wish to prepare and an approximate corresponding planning magnitude that they can afford.

⁵³ The capabilities required may also vary depending on the type of chemical and the varying prevention and responses mechanisms needed. Chapter Four will discuss these points in more detail.

capability to respond, the longer it may take to adequately provide for the needs of the victims, and thus more victims might die or sustain injuries. A medium response level might provide more services in a shorter period of time, and a high would provide a greater amount. Intuitively, more services provided for more victims would require greater capabilities on the part of the local area. For this dissertation the highest capability level for the planning magnitude will be examined as the preferred capability level. As with other emergency response programs (e.g., emergency care at hospitals, firefighting, etc.) the goal of the community, absent costs, is to save as many lives and reduce as much harm as possible. However, there may be reasons (such a cost) for decision makers to consider lesser capability levels. With the capability levels selected, decision makers can then turn next to examine cost effective approaches to achieve those levels.

Cost Effective Programs

In the third area of the planning framework, the question to be answered is, "What alternative strategies can provide the desired performance level at what cost?" It is important to realize that there does not necessarily exist a single best method to reach the desired capability. Rather, there may be a number of combinations of various preventative and mitigation strategies that provide the selected capability level. If so, then decision makers can examine the various options to determine the highest capability level for the least cost. As needed capability rises, we would expect a marginal return for the investment needed to achieve that capability. However, it is intuitive that for a lower level of capability there would be a corresponding cost that would be lower in absolute terms than the cost required for a higher level of capability. While in some cases there may be returns to scale at the lower end of capabilities, we should expect a decreasing return to scale as capabilities rise.

In Chapter Five, cost-effective options for response to chemical attacks will be explored through modeling and simulations and subsequent analysis. At that point, the total costs for the most cost-effective solutions will be examined in the final area of the planning framework.

Budgeting and Resources

The last domain of the framework can be used to answer the question "What is the right amount to apply towards this issue?" This is the area with which most local decision makers are most familiar—making funding tradeoffs between competing programs. Counter-terrorism in general, and counter-chemical terrorism specifically, must compete for funding at the local level against education, other elements of public safety, transportation issues, medical services, and many other important programs.

From the third area, the most cost-effective options, determined through modeling and simulation, were selected. However, it may be that this dollar amount, which was determined by specialists in the public safety community, when presented to the local level budget decision makers (mayor, county commissioner, city or county councils, etc.), will be determined to be too high. These same decision makers, when examining the tradeoffs between countering chemical terrorism and other programs may reduce the amount to what they perceive as the preferred budget amount. Since the budget decision ultimately determines the funding amount, the progression from quadrant one to two to three to four, may in fact also be pushed back in the other direction. With the budget being fixed at a certain amount, analysts from the previous quadrants may have to reexamine the most cost-effective options at that budget amount. Following this process, local decision makers can examine what levels response could be gained or lost by varying the budget amount.

Conclusion

When local and regional governments determine how to allocate resources to respond to an act of chemical terrorism they often follow an ad hoc process. The above methodology provides a threat and risk based approach, which includes cost-effectiveness, for local decision makers to better allocate their own limited resources and/or those funds granted to the local area from federal or state government. The next four chapters will detail each of the quadrants of the proposed framework and

how the analysis can assist in improving the counter chemical terrorism resource allocation process for an area like Los Angeles.

Chapter Three: Threat and Risk Analyses

The General Accounting Office's (GAO) reported that the government's approach to weapons of mass destruction terrorism was plagued by a lack of "threat and risk assessments that would suggest priorities and appropriate countermeasures."⁵⁴ John Parachini, a counter-terrorism analyst noted, "The GAO's observation is extremely important and should be addressed in a serious manner. The importance of the GAO view is that we lack a reasoned basis for making a case that we are spending too little, too much or just enough to combat terrorism. How much is enough remains an open question."⁵⁵ Bruce Hoffman likewise has stated, "Without a firm understanding of the threat based on rigorous, ongoing reviews of evolving or changing terrorist behavior and capabilities, continued efforts to address this problem may prove as ineffective as they are misplaced."⁵⁶ Federal counter-terrorism spending, especially in the aftermath of the September 11th attacks, has continued without a firm understanding of either threat or risk, which may lead to spending too much or too little to respond effectively to terrorism.

The first area of the planning framework, introduced in Chapter Two, includes an analysis of the threat of a chemical terrorist event in terms of probability and consequences. This chapter will 1) define the concepts of threat and risk, 2) discuss the need for and difficulties inherent in determining the threat and risk of chemical terrorism in particular, 3) outline alternative methods in determine the probability of a chemical attack taking place, and 4) suggest a practical planning magnitude in terms of the consequences of a chemical terrorist attack taking place in Los Angeles.

⁵⁴ U.S. General Accounting Office. *Combating Terrorism: Observations on Federal Spending to Combat Terrorism*. Statement of Henry L. Hinton, Jr., Assistant Comptroller General, National Security and International Affairs Division, Before the Subcommittee on National Security, Veterans Affairs, and International Relations, Committee on Government Reform, U.S. House of Representatives, March 11, 1999, p. 13.

⁵⁵ John Parachini, *Combating Terrorism: Assessing Threats, Risk Management, and Establishing Priorities*, Testimony before the House Subcommittee on National Security, Veterans Affairs, and International Relations, July 26, 2000.

⁵⁶ Bruce Hoffman, "The Debate Over Future Terrorist Use of Chemical, Biological, Radiological and Nuclear Weapons," in Brad Roberts, *Hype or Reality?: The "New Terrorism" and Mass Casualty Attacks*, Alexandria, VA: The Chemical and Biological Arms Control Institute, 2000, p. 220.

Threat of Chemical Terrorism

Currently there is an abundance of material on the potential threat of chemical terrorism, which is often misleadingly lumped with biological terrorism for the purposes of analysis. Books, reports, and academic and journalistic articles have detailed the potential use of chemicals as part of a terrorist attack and many have argued that the threat now is greater than in the past.⁵⁷ Since 1995 almost all of these articles have mentioned both the 1995 Murrah Federal building bombing in Oklahoma City and the 1993 World Trade Center bombing to indicate that large-scale terrorist attacks can take place in the United States, and go on to describe the 1995 Aum Shinkrikyo sarin gas attack on the Tokyo subway to indicate that chemical agents have been already used and may be used again.

Many of these same works posit that the risk of chemical terrorism (or that of WMD terrorism in general) is increasing since the very nature of terrorism has changed over the decades. First, while the number of incidents is declining, the number of fatalities is increasing. This trend has been linked to changes in the motivation of terrorism that was once predominately ideological and nationalistic, and has now become increasingly religious in nature, thus potentially loosening the constraints on committing deadlier acts of terrorism.⁵⁸ Since the September 11th attack more analysts see terrorists seeking to inflict higher casualties in order to create a larger sense of fear in the public. Brian Jenkins, famous for his quote, "terrorists want more people watching than dying"⁵⁹ now states, "freed from

⁵⁷ See Stern, Jessica, *The ultimate terrorists*, Cambridge, MA: Harvard University Press, 1999; Tucker, Jonathan B., ed, *Toxic terror: assessing terrorist use of chemical and biological weapons*, Cambridge, MA: MIT Press, 2000; Laqueur, Walter, *The new terrorism : fanaticism and the arms of mass destruction*, New York, NY: Oxford University Press, 1999; Carter, Ashton, John Deutch and Philip Zelikow, "Catastrophic terrorism: Tackling the new danger," *Foreign Affairs*, November/December (1998): 80-94; Second Annual Report to the President and the Congress of the Advisory Panel to Assess Domestic Response Capabilities for Terrorism Involving Weapons of Mass Destruction, *Towards a national strategy for combating terrorism*, December 2000.

⁵⁸ See, for example, Bruce Hoffman, *Inside terrorism*, Columbia University Press, 1998.

⁵⁹ Brian Michael Jenkins, *Will Terrorists Go Nuclear?* P-5541, Santa Monica, CA, RAND Corporation, November 1975.

ordinary constraints of morality...there is less inhibition to kill in quantity, and a greater willingness to die in the process."⁶⁰

In most of these publications there is also discussion of the proliferation of chemical weapons throughout the world. Notably, many of the same states that are on the State Department's list of states supporting terrorism are also some of the worst in terms of proliferating chemical weapons. Likewise, as mentioned in Chapter One, even the terrorist organizations themselves, such as al Qaeda, are discussing using chemicals, and some have proven that they have the capability to use them.⁶¹

Taken together, chemical and biological agent proliferation, the actual use of chemical weapons by Aum, the rise in fatalities in recent acts of terrorism, and the loosening of constraints on inflicting mass casualties, all indicate that the potential for terrorists using chemicals to create a large number of fatalities may be increasing. However, these observed trends do not by themselves allow us to determine the probability of a chemical terrorist attack taking place in the United States, and more specifically in a city like Los Angeles.

The threat of chemical agents is not solely in the hands of terrorists—industrial accidents also threaten the public. The single largest chemical accident (in terms of casualties) occurred in 1984 at the Union Carbide facility in Bhopal, India when methyl isocyanate, a form of cyanide used in the manufacture of pesticides, was released into the air. The escaped toxic industrial chemical (TIC) remained as a cloud over the residential area near the Union Carbide plant. As a result of the methyl isocyanate release, over 5,000 died and 200,000 were injured—many of whom are still affected by blindness and other injuries.⁶² The release of the TIC was not the result of terrorist action, but the

⁶⁰ Brian Jenkins is quoted by Karen DeYoung and Michael Dobbs, "Bin Laden: Architect of New Global Terrorism; Evolving Movement Combines Old Theology and Modern Technology in Mission without Borders," *The Washington Post*, September 16, 2001, p. A8.

⁶¹ The video tapes obtained in Afghanistan of the al Qaeda terrorist organization show a disturbing scene of chemical weapons being used to kill dogs as a trial of the chemicals for future use. See Nic Robertson, "Disturbing scenes of death show capability with chemical gas," *CNN.com*, August 19, 2002. Internet: <http://www.cnn.com/2002/US/08/19/terror.tape.chemical/index.html>.

⁶² George Buck, *Preparing for Terrorism*, Albany, N.Y., Delmar Publishers, 1998, p. 30, and U.S. Environmental Protection Agency, "Methyl Isocyanate," *Technology Transfer Network Air Toxics Website*. Internet: <http://www.epa.gov/ttn/atw/hlthef/methylis.html>.

results are similar to what terrorists might hope to achieve with an intentional TIC release. Further deaths and injuries at Bhopal resulted from a delayed emergency response. An TIC release like that in Bhopal would require a response similar to that needed in the aftermath of a chemical terrorist attack using a cyanide-based chemical agent. While Bhopal represents the extreme (to date) in terms of the casualties resulting from an TIC release, there is the potential for large-scale industrial accidents requiring emergency response throughout the United States.

Absence of Data

As noted in Chapter One, the Japanese experiences with Aum Shinrikyo are the most significant incidents of chemical weapons being used by terrorists. There have been other less well known incidents:^{63,64}

- FARC rebels in Colombia, using gasoline and "toxic gas" attacked and destroyed a police station in December 1999.
- The Middle East Newsline reported that Hamas planned chemical weapon attacks against Israeli targets in May 1999.
- In May 2000, Turkish police found 200 grams of cyanide during a raid of the Revolutionary People's Liberation Party in Istanbul. Group members were planning attacks against police stations and other public institutions.
- In February 2000, Russian soldiers found 17 barrels of chlorine attached to explosives in Chechnya—the chlorine and explosives belonged to Chechen rebels. Chechen rebels have also threatened to employ chlorine and ammonia bombs against Russian forces in Chechnya.
- Suspected terrorists in Rome, Italy were caught in February 2002 by authorities with quantities of a form of cyanide and maps of the U.S. Embassy and the city's water supply.

⁶³ The first four incidents were taken from the 1999 and 2000 WMD *Terrorism Chronology* from the Monterey Institute of International Studies.

⁶⁴ Richard Boudreaux, "4 Terror Suspects Arrested in Italy," *The Los Angeles Times*, February 21, 2002, p A3.

While there are a handful of chemical terrorism events, there is not the wealth of data commonly available for other forms of terrorism or other hazards on which risk assessments have been made. With many other hazards, such as automobile accidents or workplace injuries, we have sufficient historical data from which we can calculate risk. In the realm of terrorism analysts have collected data on bombings, hijackings, and other terrorist methods,⁶⁵ which can assist in the formation of threat and risk assessments. But this is not the case with chemical terrorism.

There exist chemical and biological terrorism databases, such as that of the Monterey Institute for International Studies (MIIS), but much of the data collected represent hoaxes and not actual use events or non-political uses⁶⁶ of chemicals. In 1999 and 2000 there were 142 biological incidents recorded by MIIS, but 127 of those were hoaxes. During those same two years there were 160 chemical incidents, but only 10 of those were hoaxes. However, of the 160 chemical incidents recorded in MIIS' database, 47 of those involved tear gas, 7 pepper spray, 13 acid (usually sprayed or poured on individuals), and 6 rat poison. Of the remaining incidents, 12 used cyanide, 4 chlorine, 4 pesticides, 2 strychnine, and 1 used arsenic. Of the 64 remaining, the chemical was either an unknown or a minor chemical, including Drano and oven cleaners. Over two-thirds of the incidents have nothing to do with terrorism or anything political in nature—the majority are chemicals used in criminal acts. Fortunately, there has been a dearth of chemical terrorism incidents to date. While history is not necessarily a predictor of the future, the lack of historical data does contribute to the difficulty in estimating the likelihood of chemical terrorist attack.

The lack of data on past uses of chemicals as weapons by terrorists does not mean that we can rule out the use of chemicals as weapons for mass casualties in the future, much as the lack of data on terrorists using airplanes in suicide missions against large buildings did not rule out the September 11th attacks from taking place. In the case of chemical terrorism, terrorist organizations

⁶⁵ The RAND/St. Andrews chronologies, the MIPT Incident Database, and the U.S. Department of State are all examples of collections of incidents of terrorism.

⁶⁶ Non-political uses of chemical or biological agents refer to criminal acts, such as extortion, revenge, etc.

such as Hamas and al Qaeda have already expressed a desire to use chemicals.⁶⁷ Thus, the general intent is already known, even if the specific plans or capabilities are not.

Methods of Threat Assessment

As defined previously, threat is the combination of the intent and capabilities of an adversary to cause harm. To better understand the threat of chemical terrorism in cities like Los Angeles, we need to first examine who might have the intent to carry out a chemical terrorist attack, and then the probability that they have the capability to execute a chemical attack.

Terrorists with WMD Intentions

We have already seen interest in chemicals by groups such as Hamas and al Qaeda. Other groups, such as the national separatist groups, the Tamil Tigers (LTTE) in Sri Lanka and the Chechen rebels, have actually used chlorine in their attacks. Jerrold Post has theorized the type of terrorist that would consider using chemical or biological terrorism in small tactical operations, as well as those who might use conventional weapons or chemical and biological weapons in large mass casualty attacks.⁶⁸ Post theorizes that only religious fundamentalist groups and religious cults would use chemicals to conduct mass casualty terrorist attacks. Aum would fit in the cult category, and groups like Hamas and al-Qaeda would fall in the religious-fundamentalist camp. However, Post defines the term "catastrophic" as mass casualties in the tens of thousands, which would most likely rule out small groups or individuals, since they would likely not have the capability to carry out such a large attack. If the goal was to use chemicals in an attack causing mass casualties, but not in the tens of thousands,

⁶⁷ Hamas stated in a memo that "when we acquire the techniques of using those materials [chemical weapons], a new gate will open in the development of suicide attacks, with the help of Allah." See World Tribune.com, "Hamas threatens to use chemical weapons against Israel," June 17, 2002. Internet: http://216.26.163.62/2002/me_palestinians_06_17.html. Osama bin Laden replied to a question in an interview with ABCNews concerning developing chemical weapons, "To seek to possess the weapons that could counter those of the infidels is a religious duty." See Rahimulla Yousafai, "Bin Laden Interview (Dec 1998)" ABCNews.com, December 22, 1998. Internet: http://abcnews.go.com/sections/world/DailyNews/transcript_binladen1_981228.html.

⁶⁸ Jerrold Post "Psychological and Motivational Factors in Terrorist Decision-Making: Implications for CBW Terrorism," in Jonathan Tucker, ed., *Toxic Terror: Assessing Terrorist Use of Chemical and Biological Weapons*, MIT Press, 2000.

more than just religious groups can be included among the potential perpetrators. Both right-wing and national-separatists should be considered. In a city like Los Angeles, the likelihood of national separatists acting is remote, though right-wing terrorists have already conducted attacks there (e.g. Bufford Furrows attack on multiple individuals in 2000).

The relative ease of acquiring toxic industrial chemicals also broadens the playing field for the terrorists. One reason that religious cults and religious-extremist groups are often considered more likely to carry out a chemical terrorist attack is their ability to amass sufficient funds and technical personnel to prepare chemical weapons. However if the chemicals are acquired by theft or released by a conventional terrorist attack on chemical installations or while chemicals are in transit, then the need for technical skills is reduced and individuals and smaller groups can pose a threat.

Analysis of the Capability to Conduct Chemical Terrorism

Amy Smithson and Leslie-Anne Levy's report, *Ataxia: The Chemical and Biological Terrorism Threat and the US Response* provides another approach to threat assessment. The report, so named because of the confusion in the then-current national response capability, helps to ground the likelihood of chemical (and biological) terrorist attack in reality. Smithson and Levy state, "Should terrorists attempt to manufacture chemical warfare agents, the technical challenges are noteworthy, but not insurmountable. The task is not a snap, as Aum Shinrikyo discovered."⁶⁹ The report detailed the difficulties terrorists would face in pursuing a chemical weapons program, and thus showed that the threat of chemical terrorism using chemical warfare agents was less than that presented in the media and by other terrorism analysts. Smithson and Levy claim that approximately \$5 million would be needed to have a manufacturing capability for chemical warfare agents in quantities necessary for mass casualties. This financial barrier would prevent many individuals or small groups from pursuing this path. Acquiring chemicals from state sponsors would also be difficult, since those states may be

⁶⁹ Amy E. Smithson and Leslie-Anne Levy, *Ataxia: The Chemical and Biological Terrorism Threat and the US Response*, Henry L. Stimson Center, October 2000, p. xii.

hesitant to give the chemical weapons to terrorists due to likely retribution from the United States, and fear of lost control over the weapons.

Where does this lead? Terrorists conduct vulnerability and risk analysis of their adversaries. They seek how to exploit security and law enforcement systems to deliver the right attack to gain maximum publicity for their cause. Most terrorists are also working off of a fixed income, and seek the biggest "bang for the buck." Thus, the lessons suggested by Ataxia would be 1) to target enclosed areas with large numbers of people and with the least amount of security so as to require smaller quantities of chemicals in the attack, and 2) to seek alternatives to manufacturing chemicals, such as stealing them or making a chemical manufacturing or storage plant the target of a conventional attack.

Characteristics of Targets

To confirm the finding of Smithson and Levy's Ataxia report, the author queried a group of ten counter-terrorism personnel (analysts and emergency responders belonging to the Terrorism Early Warning Group⁷⁰) in Los Angeles to determine what characteristics terrorists would seek in the target of a chemical attack.⁷¹ The group was selected as individuals who had conducted threat and risk assessments concerning chemical terrorism in Los Angeles. The participants were questioned individually via e-mail and their responses were forwarded to the participants for additional comment. The following suggestions represent the views of the group:

Enclosed area: Chemicals would cause more casualties in an enclosed area (e.g., movie theater, auditorium, school, enclosed mall, indoor sports arena, etc.) than if they were released in the open air. The quantity of chemicals needed for open air attacks is much greater due to dissipation, and would pose greater acquisition and dispersion challenges than the amount needed for an enclosed target.

⁷⁰ Terrorism Early Warning (TEW) group is a local level joint terrorism intelligence and assessment group comprised of local law enforcement, fire, health department, as well as representatives from federal agencies.

⁷¹ It is impossible to perfectly reflect the thinking of terrorists by using a "red team" approach, but counter-terrorism analysts and responders can provide insight on potential vulnerabilities and possible targets that terrorists might select.

- **Crowds/large amounts of people:** The ideal release location would have a large number of people in a small area so as to increase the likelihood of mass casualties.
- **High visibility:** The ideal target would have some symbolic meaning and/or would be highly visible to the public or to the media. The September 11th targets, as well as the Murrah Federal building bombing in Oklahoma City, all had symbolic value and were chosen for what they represented.
- **Chemical plants/industrial areas close to populations:** The queried group also suggested chemical plants or chemical storage facilities as ideal targets, especially those relatively close to populations, since they would solve the problem of both transportation and delivery of the chemicals. The sheer quantity of chemicals that could be released might yield similar effects to the "ideal" release in an enclosed area. These facilities, however, may lack the symbolism of other targets.

The March 1995 sarin attack in Tokyo had three of these characteristics. First, the five members of Aum punctured their eleven bags of sarin inside subway cars, an enclosed target, where the sarin gas would linger. Second, the subway cars were full of passengers, the terrorists having chosen the time of day, between 8:00 and 8:10 a.m., which was the peak of the morning rush hour. Third, the subway locations were underneath the Kasumigaseki transfer station, which was in the vicinity of the Tokyo Police Headquarters and the National Police Agency, as well as other government agencies.⁷² Although only twelve people perished from the attack, the incident can be viewed as successful in that it caused large-scale panic among the victims, the broader Japanese public, and throughout the world.

If terrorists were using toxic industrial chemicals in Los Angeles they might attempt to extract the most effectiveness out of a less toxic material than military grade agents, by following similar target characteristics to those of Aum Shinrikyo's Tokyo attack, or by targeting a large chemical facility. Like

⁷² David E. Kaplan, "Aum Shinrikyo (1995)," in Jonathan B. Tucker, *Toxic Terror: Assessing Terrorist Use of Chemical and Biological Weapons*, MIT Press, 2000.

the Japan attack, the casualties may not be as high as the terrorists would hope, but the anxiety raised by such an attack might mirror or surpass that created by Aum's efforts.

Toxic Industrial Chemicals vs. Military Chemical Warfare Agents

Much of the current literature on chemical terrorism and most of the chemical training provided through the NLD Act focuses on military chemical warfare agents (CWA).⁷³ Chemical warfare agents are typically classified as either nerve agents, vesicants (sometimes referred to as "blister agents"), pulmonary agents (also called "choking agents"), and cyanides (also called "blood agents"). The counter-chemical terrorism literature and training material provided to emergency responders are almost carbon copies of military guidebooks. For example, the chemical terrorism segment *Janes' Chem-Bio Handbook: California Law Enforcement* was written by the same expert, Frederick R. Sidell, MD, who compiled chemical warfare procedures for the U.S. Army. There are many similarities between the Janes' handbook and the U.S. Army's Medical Research Institute of Chemical Defense's Medical Management of Chemical Casualties Handbook. They both describe the chemicals potentially seen in attacks as either nerve agents, cyanide, vesicants/blister agents or pulmonary agents, and both include sections on riot control agents. They also both describe almost the same agents within each of these categories (e.g., tabun, sarin, soman, VX as examples of nerve agents).

The inclusion of CWAs in counter-terrorism literature is due in part to military expertise with these chemicals from decades of experience and experimentation. Additionally, when the NLD Act was written, the task for managing the training was given to the Department of Defense, which relied on its lengthy experience with chemical warfare agents in the creation of its training material. However, as noted above, the training material was created without an assessment of the threat posed to the communities to be trained. It appears firefighters in Los Angeles are less likely to face VX in a terrorist

attack than they are to face a weaponized organophosphate insecticide; parathion and other insecticides are available throughout Los Angeles County, but VX would have to be manufactured, stolen from military stockpiles, or brought in from outside the country. The GAO notes that "Many familiar with industrial chemicals, such as officials from the FBI, the Environmental Protection Agency (EPA), the Coast Guard, and local hazardous materials (HAZMAT) teams, believe that industrial chemicals may also be a weapon of choice in terrorist attacks because they can be easily obtained and dispersed."⁷⁴

This is congruent with the beliefs of those tasked to examine and respond to terrorism in the Los Angeles community. A similar group of representatives of fire, law enforcement, and public health agencies, as well as terrorism and policy analysts, were again queried for this dissertation on topics such as characteristics of likely targets, as well as their thoughts on whether terrorists would use chemical warfare agents or toxic industrial chemicals (TICs). The session's participants, as a whole, agreed that TICs were the most likely chemicals to be used in a terrorist attack—20 to 1 odds were suggested as the relative likelihood of TICs being used compared to CWAs.⁷⁵ This reflects the viewpoint from the Los Angeles case study that Jonathan Schachter and this dissertation's author co-wrote in 2000 as part of the Gilmore Commission's second annual report, namely

Local responders have complained about the overwhelming emphasis in federal training programs on military quality CBRN weapons. For a host of reasons, it is widely thought that the likelihood of a CBRN attack is low, and that the likelihood of such an attack using weapons grade material is even more remote. Thus, the local responders would prefer to train based on realistic scenarios involving agents more likely to be seen in the United States today and in the near future (i.e., common

⁷³ See Brennan, Richard J., et al. "Chemical warfare agents: Emergency medical and emergency public health issues." *Annals of Emergency Medicine*. 34.2 (August 1999), 191-204; Sidell, Frederick R., William C. Patrick III, and Thomas R. Dashiell. *Jane's chem-bio handbook*. Alexandria, VA: Jane's Information Group, 1999; Buck, George. *Preparing for terrorism: an emergency services guide*. Albany, N.Y., Delmar Publishers, 1998; Institute of Medicine, Committee on R & D Needs for Improving Civilian Medical Response to Chemical and Biological Terrorism Incidents, National Research Council (U.S.), Board on Environmental Studies and Toxicology, *Chemical and biological terrorism: research and development to improve civilian medical response*, Washington, DC: National Academy Press, 1999.

⁷⁴ GAO/NSIAD-99-110 Combating Terrorism: Use of National Guard Response Teams is Unclear.

⁷⁵ The ratio suggested is not intended to be used as a indicator of the probability of a CWA attack by terrorists, rather a gauge of the respondents' belief that TICs are the most likely choice of terrorists.

industrial chemicals, etc.). As one TEW participant put it, "Vic from Ventura ain't got VX."⁷⁶

If the goal of the terrorists is to engender hysteria within the population as a whole from a chemical terrorist attack, loss of life is desirable only insofar as it advances that goal. As in the case of a radiological bomb that may not kill many individuals, the fear generated by such an incident would be disproportionately great. The anthrax letters in the fall and winter of 2001 killed only five individuals, but caused large-scale panic across the nation. While using toxic industrial chemicals might not kill as many as would chemical warfare agents, the likelihood of terrorists acquiring TICs is higher and the fear generated by their use might be just as great during and after such a terrorist incident as it would be during or after an attack involving military grade chemicals.

The simulations or analysis for this dissertation are not based on terrorist use of chemical warfare agents, but rather on toxic industrial chemicals. This decision was based on the estimated much higher probability of TICs being used, as well as the fact that preparedness for terrorist use of toxic industrial chemicals would also be applicable to industrial accidents. Most terrorist groups attempt to find the path of least resistance, so toxic industrial chemicals, and those TICs that are the easiest to acquire, may be their first choice.

For the simulation and modeling portions of this dissertation, based on realistic industrial chemical threats in the county (i.e., what chemicals are present and may pose a threat if used in a terrorist event or released in an industrial accident?), four chemicals were selected after consulting with representatives of the Los Angeles HazMat and Department of Health Services as well as an emergency room toxicologist and a professor of environmental science. The four chemicals that stood out were chlorine, hydrogen cyanide, parathion and phosgene.⁷⁷

⁷⁶ *The Second Annual Report of the Advisory Panel to Assess Domestic Response Capabilities for Terrorism Involving Weapons of Mass Destruction: Toward a National Strategy for Combating Terrorism*, RAND, 2000. We conducted numerous interviews of Los Angeles emergency responders to compile a case study of counter-terrorism efforts in the area.

⁷⁷ Chlorine, phosgene and hydrogen cyanide are all considered toxic industrial chemicals, but they are also chemical warfare agents. For this reason, and for their availability in the Los Angeles region, they are of concern for emergency responders.

Chlorine (CL) is the most prevalent of the four chemicals focused on in this dissertation and is available and transported in bulk by rail and truck throughout the county. HazMat units in Los Angeles County often respond to chlorine incidents, typically caused by either inappropriately mixing chemicals together, or leaks. Because of its abundance and ease of access, the likelihood of its use might be perhaps the greatest.

Chlorine gas causes acute damage to both the upper and lower respiratory tract. The damage to the respiratory tract, caused by inflammation, leads to the lungs swelling and filling with fluid. While the irritation to the lungs is immediate, the serious damage (pulmonary edema and hypoxia) may not be recognized until later when the victim becomes symptomatic.⁷⁸ Response to chlorine gas requires the victim to be removed from the source of the gas. If the victim was exposed to just the gas itself, there may be little need for decontamination other than removing their clothing (the outer layer may be all that is required)—fresh air will help remove the gas. However, if the victim was exposed to the liquid form of chlorine, this will require full decontamination with soap and water. Oxygen and possible ventilation may be required after decontamination is performed, as well as observation at a hospital for possible respiratory damage.⁷⁹

Hydrogen cyanide (AC) is also a threat, but it is not usually transported in bulk as such. It can be purchased in smaller quantities, (e.g., five pounds) but rarely have Los Angeles HazMat units responded to an incident involving hydrogen cyanide. On the other hand, potassium cyanide in powder form is easily acquired in the county—in fifty-pound bags or larger—and can be mixed with any common acid to produce hydrogen cyanide. The potential of a terrorist acquiring large quantities of potassium cyanide and converting it to hydrogen cyanide is of great concern in the county.

Of the four selected chemicals, hydrogen cyanide is the most toxic and has the shortest latency, or time before the onset of symptoms. Cyanide prevents cells from using oxygen. Within 30

⁷⁸ Eli Segal and Eddy Lang, "Toxicity, Chlorine Gas," *eMedicine*, 23 May 2001. Internet: <http://www.emedicine.com/emerg/topic851.htm>.

⁷⁹ Sidell, Frederick R. et al., *Jane's Chem-Bio Handbook*, Jane's Information Group. Alexandria, VA: 1999. p. 128-9.

seconds victims exposed to a lethal dose can lose consciousness. They cease to breathe within three to five minutes, and heart activity stops in five to eight minutes.⁸⁰ Those exposed to a high, but less than lethal, dose will require oxygen and possibly antidote. Those with a lower exposure may not require emergency medical attention once exposed to fresh air. The removal of the outer layer of clothing and exposure to fresh air may be all that is required for decontamination if the victim was exposed solely to the vapor, but full decontamination—showering with soap and water—is required if exposed to the liquid form.

Parathion, or any industrial strength organophosphate insecticide (e.g., malathion), is a constant threat in Los Angeles. Parathion is manufactured in the U.S., but only available for retail sales in its pure form outside of the country. It can be purchased in Mexico and brought across the border fairly easily.⁸¹ The stored quantities of insecticides such as parathion are typically smaller than those of chlorine, but it can be found in bulk and is stored and manufactured in Los Angeles.

Parathion is similar to military nerve agents, in that it inhibits cholinesterase (prevents the nerve cells from properly functioning), but it is less toxic in nature than military nerve agents by more than an order of magnitude. Exposure to the liquid can quickly cause respiratory problems, difficulty with vision, miosis (the constriction of the pupils), nausea, diarrhea and/or death—all symptoms similar to those of nerve agent exposure.⁸² Early recognition and timely medical intervention is important, including moving the victims to fresh air, decontamination (preferably with soap and water) and providing atropine and an oxime as an antidote.⁸³ Fatalities have occurred in humans from parathion from exposure through skin contact, inhalation, and ingestion.⁸⁴

⁸⁰ Steven I. Baskin and Thomas G. Brewer, "Cyanide Poisoning," *Medical Aspects of Chemical and Biological Warfare*, Office of the Surgeon General, United States Army, 1997 p. 276-277.

⁸¹ This premise is based on a discussion of a HazMat official who cited several instances of responding to parathion spills of parathion brought into Los Angeles from Mexico.

⁸² Sidell, Frederick R. et al., p. 74.

⁸³ Debra Slapper, "Toxicity, Organophosphate and Carbamate," *eMedicine*, 5 June 2001. Internet: <http://www.emedicine.com/emerg/topic346.htm>.

⁸⁴ Oregon State University, "Parathion," Exttoxnet, Extension Toxicology Network, September 1993. Internet: <http://ace.ace.orst.edu/info/exttoxnet/pips/parathio.html>.

Phosgene (GC) may be the least common of the four chemicals in the Los Angeles County, but the National Academy of Sciences estimates that one billion pounds of phosgene is produced nationally for use in the manufacture of plastics.⁸⁵ While it is often packaged in small quantities, it can be stored and shipped in larger amounts.

A pulmonary agent, phosgene has a longer latency than the other three selected chemicals, but the delay in onset of severe symptoms can mislead responders in estimating its potential to cause great harm to the victims. Like chlorine, phosgene affects the respiratory tract and causes a similar effect, although it may not be as instantly irritating as chlorine. Symptomatic effects may include shortness of breath. Patients who are exposed to phosgene should be removed from the chemical site and remove their outer layer of clothing. Full technical decontamination is needed if liquid phosgene is on their clothes or skin. These exposed victims need to be forced to rest, since even mild exertion can lead to an earlier onset of severe symptoms.⁸⁶ While there is no antidote for phosgene, the exposed victims will need to receive oxygen and be forwarded to a hospital for further observation and treatment (continued oxygen, IV, possible ventilator, and medication to treat symptoms). While decontamination and initial medical treatment should take place quickly, enforced rest is more important than rushing these victims to hospitals in the first hour after exposure. Those victims that show symptoms within six hours after exposure will not likely survive.⁸⁷ However, lives can be saved and injury avoided through timely medical treatment, such as ventilation with oxygen and rest.

A brief table of characteristics of these four chemicals is provided in Table 3.1 below. The lethal concentration over time that will kill 50 percent of those exposed (LCt50) is listed in the first column in the table. This shows that parathion is the most lethal when inhaled, followed by hydrogen cyanide. However, parathion also has the least vapor pressure, highest boiling point, and highest vapor density, which means it is less likely to evaporate, turn into its gas form, and if it is in gas form it is

⁸⁵ National Academy of Sciences. *High-impact terrorism: Proceedings of a Russian-American workshop.*

Committee on Confronting Terrorism in Russia. National Academy Press, Washington, DC: 2002, p.134.

⁸⁶ Medical Research Institute of Chemical Defense, "Medical Management of Chemical Casualties Handbook," Aberdeen Proving Grounds, MD. 1995, p. 100.

⁸⁷ Ibid, p.103.

the heaviest (i.e., will tend to settle in low areas). Chlorine, on the other hand, evaporates the quickest (i.e., low boiling point) and quickly dissipates through an enclosure (i.e., high vapor pressure). Chlorine, like parathion and phosgene, is heavier than air, so will collect in low areas. Phosgene is similar to chlorine, but has a higher boiling point and lower vapor pressure. Hydrogen cyanide quickly evaporates at room temperature and is slightly lighter than air. It also easily mixes in water, while phosgene will break apart (hydrolyze). Chlorine is soluble in water (i.e., able to wash in water), but parathion is not very soluble (i.e., it will require soap to help it wash off in water). Each of the four chemicals, while not as toxic as chemical warfare agents, has the ability to cause death or serious injury to those exposed.

	LCt50 (mg-min/m ³)	Boiling Point	Solubility in water	Vapour pressure, kPa at 20°C	Relative vapour density, (air = 1)
Chlorine	3,000	-34°C	g/100 ml at 20°C: 0.7	673	2.5
Hydrogen Cyanide	2,500-5,000	26°C	miscible	82.6	0.94
Parathion	1,500-2,000	157°C	g/100 ml at 25°C: 0.0024	0.00005	10
Phosgene	3200	8°C	hydrolyzes	161.6	3.4

Table 3.1 Properties of Four Chemicals

The amount of these chemicals needed to expose 1,000 people in an enclosed area (e.g., movie theater, shopping mall, civic center, etc.) is not out of the grasp of terrorists. Chlorine is often transported in trucks filled with over 20,000 gallons, when 1,000 gallons would easily expose 1,000 persons. Phosgene would take a similar amount. Only around 30 kilograms of hydrogen cyanide is needed to expose 1,000 people in an enclosed area, while parathion would need to be a higher amount, around 100 kilograms.

Methods of Risk Assessment

Since the lack of past data makes it difficult to determine the probability of an attack taking place, other methods can be used to drive analysis. The most common method incorporates the

perceived risk of experts or policymakers. When considering uncertainties or rare events in the absence of data, experts' opinion might not be that much different from others', and there is often little certainty that the expert's opinion is more accurate than any other. Reliance on a single expert may be no more than a gamble that the individual is correct. Therefore, in order to "hedge," it may be appropriate to use multiple experts rather than to rely on any one single expert.⁸⁸ Clemen and Winkler see using multiple experts as a means of increasing the sample size when dealing with a subjective "soft scientific" experiment. By consulting multiple experts the information base is enlarged.⁸⁹ Likewise, Hinsz, Tindale, and Vollrath, see in the face of high levels of uncertainty groups that pool their expertise tend to correct each other's errors, thus leading to a higher likelihood of accuracy.⁹⁰

On the other hand, Falkenrath argues that often the counter-terrorism experts that are used to estimate risk are area or group-specific specialists, and may not be able to provide a general probability for the likelihood of a WMD terrorist attack.⁹¹ Since perceived risks are based on the past experience and/or knowledge of the individual, the limited past use of chemical terrorism might bias these experts. Most terrorist groups have not tried to use chemical weapons as part of their campaigns, so the counter-terrorism experts focusing on these groups may not have the expertise to give accurate input on the likelihood of chemical terrorism.

Survey

In order to assess the probability of a chemical terrorist attack in Los Angeles in light of the absence of data, and in keeping with the methodology proposed by Bier, Clemen and Winkler, twenty participants of the Terrorism Early Warning (TEW) group in Los Angeles were surveyed, asking them the following question:

⁸⁸ Bier, Vicki M., et al., "A survey of approaches for assessing and Managing the Risk of Extremes," *Risk Analysis*, Vol. 19, 1999.

⁸⁹ Clemen, Robert T and Robert L. Winkler, "Combining Probability Distributions from Experts in Risk Analysis," *Risk Analysis*, Vol. 19, No. 2, 1999.

⁹⁰ Hinsz, V.B., R.S. Tindale, and D.A. Vollrath, "The emerging conceptualization of groups as information processors," *Psychological Bulletin*, 121(Vol. 1), p. 43-64.

⁹¹ Falkenrath, Richard A. "Analytic models and policy prescriptions: Understanding recent innovation in U.S. counterterrorism," BCSIA Discussion Paper 2000-31, ESDP Discussion Paper ESDP-2000-03, John F. Kennedy School of Government, Harvard University, October 2000.

In the next five years what do you feel is the probability of a single chemical terrorist event in Los Angeles taking place that would expose...

approximately 10 individuals?

approximately 100 individuals?

approximately 1000 individuals?

They were asked to give a probability ranging from 0% to 100% for each of the three questioned amounts of exposed victims. The results of the survey are shown in Figure 3.1 below.⁹²

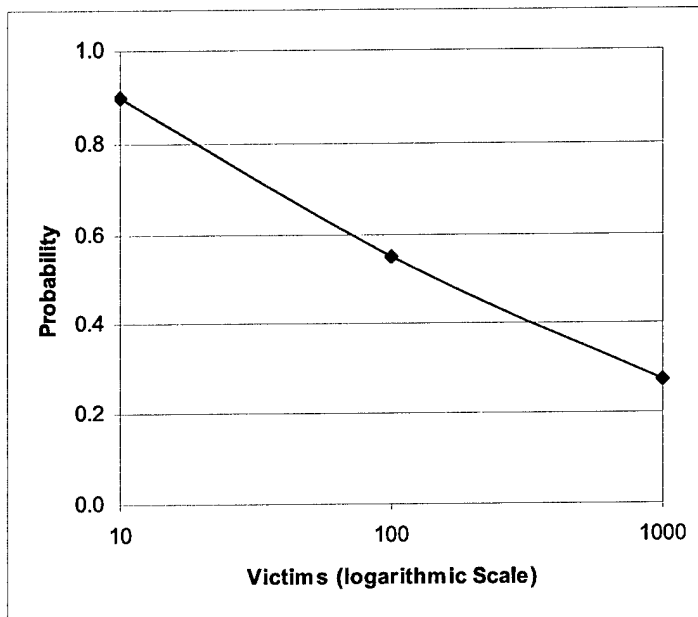


Figure 3.1 Perceived Risk of Chemical Terrorism over Next Five Years by TEW Participants

The distribution of the survey results indicates a vast range of opinions. The median of the responses for probability of 1000 victims was .275. While many of the respondents' estimations were

⁹² The equation used to average the scores is represented as $p(\theta) = \sum_{i=1}^n w_i p_i(\theta)$, and is called a linear

opinion pool. This equation uses a weighting mechanism, where w_i is a non-negative number and its sum equals one, representing the relative expertise of the experts—if it is determined that one or more of the experts in the pool may have more expertise than others, and therefore their probability should be given more weight. If the experts' opinions are all considered equally valid, then they are each given the same weight of

$w = \frac{1}{n}$, where n is the number of the experts in the pool.

close to the median, two of the responses felt there was a 100% chance of an attack with 1000 victims, while two others thought the likelihood for the same attack was approximately 0.001%. Such a variance among the respondents illustrates the lack of agreement among experts on the risks. In the absence of sufficient data to base estimation, it is best to find other methods, since the experts' judgment might also be affected by the lack of data. When their estimates are averaged, the results look sensible, however the average does not indicate the vast difference in opinions. If possible, it might be useful to take into consideration the basis upon which the experts gave their estimates, rather than simply to look at the average. Barring that, it is probably better not to use such a pseudo-scientific approach and to go with another method to assist in the risk assessment. However, when there is new data present that may directly improve an estimation of the risk, then policymakers might wish to hear the risk estimated by multiple experts.

Two Alternatives

Analysts and policymakers can also use relative risks to help judge the likelihood of a future incident. Relative risks refer to the odds of experiencing an incident in comparison to other similar incidents, such as injury or death through various causes. By comparing a risk to others that are faced in day-to-day life, policymakers can better estimate the probability or better prioritize risk mitigation strategies. Table 3.2 below shows the relative risk based on 1998 National Safety Council statistics concerning "What are the Odds of Dying?" The table first shows the number of deaths by the type of injury, and then shows the odds of dying by that type of injury for that year and the lifetime odds. The odds of dying by any type of injury (in the United States) is one in 1,796 for the year, or one in 23 for a lifetime.

Type of Accident or Manner of Injury ⁹³	Deaths, 1998	One year odds	Lifetime Odds
TOTAL DEATHS DUE TO INJURIES	150,445	1:1,796	1:23
Motor-vehicle	43,501	1:6,212	1:81
All Homicide Deaths	17,893	1:15,104	1:197
Drowning	3,964	1:68,176	1:889
Fall on or from stairs or steps	1,389	1:194,563	1:2,537
Air and space transport	692	1:390,532	1:5,092
Poisoning by gases and vapors	546	1:494,960	1:6,453
Cataclysmic storms, and floods resulting from storms	204	1:1,324,745	1:17,272
Lightning	63	1:4,289,651	1:55,928
Terrorism (International) ⁹⁴	12	1:22,520,666	1:293,620
September 11, 2001 terrorist attacks ⁹⁵	3000	1:90,082*	1:1174*

Table 3.2 Relative Risks of Dying

Based on the 1998 data in the table, the odds of dying from a terrorist attack were less than those of being killed by lightning. This might lead analysts and policymakers to assess the level of importance of terrorism mitigation strategies as less than that of protecting the public from lightning. However, based on the number of fatalities from the September 11th attacks, the odds of death by a terrorist act lie between those of dying by drowning or by falling down stairs.

If policymakers relied solely on relative risks to prioritize their decisions, counter-terrorism efforts would not receive much attention. This is wrong for two reasons. First, prior to the September

⁹³ Adapted from National Safety Council, "What are the Odds of Dying?" October 2001. <http://www.nsc.org/lrs/statinfo/odds.htm> One-year odds are approximated by dividing the 1998 population (270,248,000) by the number of deaths. Lifetime odds are approximated by dividing the one-year odds by the life expectancy of a person born in 1998 (76.7 years).

⁹⁴ Twelve Americans were killed in 1998 in acts of international terrorism.

⁹⁵ The September 11 terrorist attacks took place in the year 2002, whereas the statistics from the table are from 1998. The number of people who died in the attack is an approximation, as the odds, since the population has changed from 1998 to 2002. Yet the numbers and odds are merely illustrative of the relative risk of the threat of terrorism.

11th attacks, the small number of deaths each year from terrorism indeed might have shown the accurate relative risk, but it would not have captured the emotional, social, political or even economic cost of those terrorist incidents. The goal of terrorists is not to kill people, but to create political or social change through the fear generated by the attack.⁹⁶ Thus the number of people killed and injured in the attack may help determine the amount of fear generated, but even a smaller number of fatalities can have a large social affect on a population. The economic costs—including the actual damage of life and property, as well as the cost of changed behavior (e.g., reduction in people flying after September 11, 2001)—of the terrorist attacks are also not always reflected in relative risks. Merely examining the number of fatalities and the relative risk in comparison to other manners of death is to ignore the social impact caused by an *intentional* political act to create an atmosphere of fear.⁹⁷ The fact that as a society we are risk adverse motivates decision makers to do something to better mitigate the effects of terrorism.

Secondly, relative risks, such as those listed in Table 3.2, show the historical risks, not the future risks. If terrorists realize success in incidents they may increase the frequency of their attacks. They may also feel the need to increase the severity of their attacks to garner increased media attention. Thus the relative risk may potentially increase through rises in both frequency and severity, and policymakers who solely focused on historical relative risks would inadequately prepare for future terrorist events.

⁹⁶ The Federal Bureau of Investigation's definition of terrorism is as follows: "Terrorism is the unlawful use of force or violence against persons or property to intimidate or coerce a government, the civilian population, or any segment thereof, in furtherance of political or social objectives."

⁹⁷ See the Terrorism Research Center's "Terrorism: Can You Trust Your Bathtub," September 12, 1996, <http://www.terrorism.com/terrorism/bathtub.shtml>, which this dissertation's author wrote after attending a CATO conference where the institute's chairman stated more people die from slipping in their bathtubs than from terrorism. See also Richard Falkenrath's "Analytic Models" previously quoted, where he likewise describes the social magnification of terrorism.

Military Standard 882C

Military Standard 882c⁹⁸ is a method for program managers to determine risk or hazards and to determine the proper response to mitigate or reduce the level of risk to a manageable level. The personnel tasked to this process examine a given program to estimate the probability of occurrence of the risk/hazard, and determine its severity. This is not an exact science, and relies upon the frequency of past occurrences or the estimates of experts of potential frequency and severity. The probability is broken down into groups: A. frequent, B. probable, C. occasional, D. remote, and E. improbable.⁹⁹ Severity is categorized as I. catastrophic, II. critical, III. marginal, and IV. negligible.¹⁰⁰ While the Military Standard 882c has its own definitions for severity, for this dissertation the categories are defined as negligible (no deaths), marginal (1 to 10 deaths and/or severe injuries), critical (11 to 1,000 deaths and/or severe injuries), catastrophic (greater than 1,000 deaths and/or severe injuries). When placed on a matrix together, the elements of probability and severity create a table as depicted below (see Table 3.3).

Probability of Occurrence	Severity Level			
	I. Catastrophic	II. Critical	III. Marginal	IV. Negligible
A. Frequent	I A	II A	III A	IV A
B. Probable	I B	II B	III B	IV B
C. Occasional	I C	II C	III C	IV C
D. Remote	I D	II D	III D	IV D
E. Improbable	I E	II E	III E	IV E

Unacceptable
Undesirable
Acceptable-Requires Review
Acceptable- No Review

Table 3.3 Military Standard 882c

⁹⁸ See GAO, "Combating Terrorism: Threat and risk Assessments Can Help Prioritize and Target Program Investments," GAO/NSIAD-98-74, April 1998, and well as U.S. Department of Defense, Military Standard 882C, Appendix A, Guidance for Implementation of System Safety Program Requirements.

⁹⁹ The probability categories are defined in 882C as the following: Frequent—likely to occur frequently; Probable—will occur several times in the life of an item; Occasional—likely to occur some time in the life of an item; Remote—unlikely but possible to occur in the life of an item; and Improbable—so unlikely, it can be assumed occurrence may not be experienced.

¹⁰⁰ The severity categories are defined in 882C as the following: Catastrophic—death; Critical—severe injury; Marginal—minor injury; Negligible—less than minor injury.

Risk levels are then determined by where the potential hazard/risk lies in the matrix. Those shaded in black (IA, IIA, IIIA, IB, IIB and IC) are considered "unacceptable" risks and countermeasures are required to reduce the level of risk. Those hazards/risks with the dark shade of gray (ID, IIC, IID, IIIB and IIIC) are labeled as "undesirable" and a decision is required by leaders to determine how to best deal with these risks. Those hazards/risks in white (IE, IIE, IIID, IIIE, IVA, IVB) are considered "acceptable," yet they still require a review by leaders. Lastly, those hazards/risks in light gray (IVC, IVD and IVE) are also considered "acceptable" but need no review by leaders. The breakdown within the matrix, represented by the shading, is applied universally, regardless of the risk/hazard.

Chemical terrorism can be placed in the matrix to help determine what actions, if any, should be taken to reduce the level of risk or to decide how to prepare for or respond to an event. Since the severity could take several forms—from one victim to perhaps a thousand or more—it may be best to look at more than just one category. If a chemical terrorist event took place, it is safe to estimate that it would not be negligible.¹⁰¹

Determining the probability of a chemical terrorist event is more problematic than determining its severity. It may be safe to assume that chemical terrorism is not likely to be a "frequent" event, since terrorism in general does not have a high frequency and it is even lower in Los Angeles. Even "probable" may be too high an estimate for chemical terrorism. The likelihood of chemical terrorism occurring in Los Angeles would fall in the "occasional" (likely to occur sometime) to "remote" (unlikely but possible to occur) categories. Without more data it would be best not to consider the likelihood of a chemical terrorist attack as improbable (so unlikely it can be assumed occurrence may not be experienced).

Taking a conservative approach, the risk level for chemical terrorism lies somewhere in the region of IIC, IIIC, ID, IID and IIID—see Table 3.4 below.

¹⁰¹ It may be argued that if the event took place without any victims that it could be considered negligible, yet even the fact that terrorists have the capability to conduct a chemical terrorist event and demonstrated it without casualties, would achieve the psychological effect, at least in part.

Probability of Occurrence	Severity Level				
	I. Catastrophic	II. Critical	III. Marginal	IV. Negligible	
A. Frequent	I A	II A	III A	IV A	Unacceptable Undesirable Acceptable-Requires Review Acceptable- No Review
B. Probable	I B	II B	III B	IV B	
C. Occasional	I C	II C	III C	IV C	
D. Remote	I D	II D	III D	IV D	
E. Improbable	I E	II E	III E	IV E	

Table 3.4 Military Standard 882c and Risk Level for Chemical Terrorism in Los Angeles

This would indicate that the risk is mainly in the undesirable category and requires decisions from leaders on how to deal with the hazard and what countermeasures should be considered to reduce the risk. This approach is useful for analyzing a single site, but the likelihood of terrorist incidents increases when examining multiple sites. Since the likelihood of a chemical terrorist event taking place somewhere in Los Angeles is greater than the likelihood of a chemical terrorist event occurring at a single location within Los Angeles, analysts using the 882C approach should define their categories appropriately multiple events and multiple locations.

Summary of Threat and Risk Methods

This chapter has described how the absence of meaningful data on chemical terrorism makes it difficult to estimate the probability of a future event. However, we have seen that terrorists have decreasing inhibition to inflict higher casualties, and they are starting to discuss and even use chemical weapons. Terrorists do not need to use military chemical warfare agents in acts of terrorism, but rather can take the path of least resistance and acquire toxic industrial chemicals, which would provide a similar psychological affect, if not as high a mortality rate. Various risk assessment methodologies lead to the conclusion that decision makers should consider strategies to respond to acts of chemical terrorism. Gaining more information is necessary, but is not necessary to start considering what capabilities are needed to augment response capabilities if a planning magnitude can be selected.

The Planning Magnitude Approach

The planning magnitude is not entirely dependent upon an accurate risk probability, if sufficient data are present, having a planning magnitude that reflects the present risk is optimal. Nevertheless, a magnitude can be chosen that can help drive the planning and budget process. The planning magnitude represents a standard according to which the response system is measured. If credible intelligence is able to better inform the threat and risk assessment process, the planning magnitude can be modified to reflect the change in data.

A planning magnitude should be large enough that it reflects a "worst-case," but not a "catastrophic case."¹⁰² If the planning magnitude reflects the latter, then policymakers may either deem that the likelihood is too small or the response required is too high for a realistic resource allocation. Thus, a practical planning magnitude should stretch the present capabilities of the area, but should not cause policymakers to just give up. Policymakers should choose a magnitude that reflects both the level of preparedness that deemed needed as well as a level that can be afforded.

In the Tokyo chemical attack in 1995, over 5,000 casualties were reported. However, over 4,000 of those victims were psychosomatic, the "worried-well." Although only 12 died, approximately 1,000 casualties required some type of medical attention as a result of the nerve agent. For this dissertation, and based in part on the Tokyo experience, I will use a planning magnitude of 1,000 casualties. This represents a large enough victim pool that it will severely tax the response capabilities, but not so large as to be deemed impossible in terms of likelihood and potential response. The

¹⁰² A "worst-case" scenario represents an incident that pushes the upper limit of the responders. This may be an incident that involves hundreds to thousands of victims. A "catastrophic-case" scenario might involve tens of thousands of victims. A catastrophic-case scenario might be so large in scope that decision makers refuse to even consider potential mitigation strategies.

dissertation will also take a parametric approach by examining the response at other levels (e.g., 100, 500, 5,000, and 10,000 victims).

Chapter Four: Magnitude and Capabilities

This chapter examines the planning magnitude and the capabilities needed to respond to an attack of a given magnitude. After examining the relationship between magnitude and capability, the chapter will outline the various capabilities Los Angeles currently has to counter and respond to a chemical terrorist incident.¹⁰³ Additionally, this chapter will discuss a modeling and simulation approach that considers the present baseline level to respond to a chemical attack.

In the preceding chapter a planning magnitude of 1,000 victims was chosen as a reasonable level of consequence for which the city of Los Angeles might prepare, and four toxic industrial chemicals (hydrogen cyanide, phosgene, chlorine and parathion) were selected to provide a benchmark for both risk and response. The emergency response to these chemicals are similar, but not identical. In response to each chemical, emergency responders will want to remove the victims from exposure by physically moving the victims away from the chemical, and cleaning residual chemicals from the victims' bodies if needed (this is done through removal of clothing and decontamination). Other emergency medical services, such as providing oxygen and antidote, will be offered as needed.

As seen in Table 4.1 below, each of the selected chemicals is different in the type of response needed. Two (hydrogen cyanide and parathion) require an antidote. The time for survival without medical attention after exposure to a lethal concentration of the chemical is short for hydrogen cyanide (a matter of minutes), where as the others take more time (hours).

¹⁰³ The counter-chemical terrorism capabilities discussed are those officially and publicly known in the city and county of Los Angeles. However there may be other capabilities in the Los Angeles Metropolitan area that are not known or addressed in this dissertation. Those capabilities may be of assistance in an actual incident.

	Antidote	Decon	Oxygen	Survival Time
Hydrogen Cyanide (AC)	Y	N*	Y	Short
Phosgene (GC)	N	N*	Y	Medium
Parathion	Y	Y	Y	Medium
Chlorine (CL)	N	N*	Y	Medium

*Decontaminated if exposed to liquid form of chemical

*Table 4.1 Response Characteristics of Selected Chemicals*¹⁰⁴

Some might argue that, in theory, only parathion requires decontamination, while the other three require decontamination only if the victim was exposed to the chemical liquid (i.e., chemical splashed on them) rather than the vapor. This is due to the rapid rate that the other chemicals evaporate (thus the chemical does not penetrate through the skin). However, chemical warfare expert Frederick Sidell suggests "All chemical casualties require decontamination. One might argue that a casualty exposed to vapor from a volatile agent, such as cyanide or phosgene, or from some of the volatile nerve agents does not need to be decontaminated. However, one can seldom be certain that in a situation in which vapor and liquid both exist, some liquid is not also present on the casualty."¹⁰⁵ Thus, according to LAFD and LACoFD doctrine (as well as the doctrine for emergency responders nationwide), all exposed victims (whether exposed to vapor or liquid) receive decontamination before going to or entering hospitals or receiving emergency medical attention.¹⁰⁶ Exposure to the chemical is determined through questioning (or by visual determination) during triage by on-scene paramedics, or by a physician or nurse conducting triage at the hospital.

¹⁰⁴ "Exposure to the liquid form of the chemical" would indicate that liquid chemical was present on the victim's skin or clothing.

¹⁰⁵ Frederick Sidell, "Triage of Chemical Casualties," *Medical Aspects of Chemical and Biological Warfare*, Office of the Surgeon General, United States Army, 1997, p. 340. This is similar to the National Fire Protection Association recommendation, "When in doubt about contamination, decontaminate all involved personnel...." National Fire Protection Association, *NAFP 471: Recommendation practice for responding to hazardous materials incidents, 2002 Edition*. NFPA: Quincy, MA. 2002. p 13.

¹⁰⁶ Over 20 percent of emergency medical professionals in one of Tokyo's hospitals showed signs of secondary exposure to the gas sarin during the Aum Shinrikyo incident in 1995. See, Sadayoshi Ohbu, et al., Sarin Poisoning on Tokyo Subway, *Southern Medical Journal*, Vol. 90, No. 6, (June 1997). Internet: <http://www.sma.org/smj/97june3.htm>. This finding is further evidence that emergency responders should always decontaminate victims to ensure not only that the chemical will not continue to have an effect on the victims, but to also ensure that medical personnel are not contaminated by the victims.

Types of Decontamination

"Decontamination is the process of removing or neutralizing hazardous materials on people or equipment."¹⁰⁷ As noted above, the victim may have become contaminated by exposure to the liquid form of the chemical or possibly through exposure to the vapor form of the chemical. Some chemicals, such as phosgene, may quickly evaporate and leave little remaining contamination on the victim. Other chemicals, such as parathion, if sprayed onto the victim will not easily evaporate and require more thorough decontamination. Furthermore, "[s]ince the most important aspect of decontamination is the timely and effective removal of the agent, the precise methods used to remove the agent are not nearly as important as the speed by which the agent is removed."¹⁰⁸

Decontamination is an essential part of emergency medical response to either a chemical terrorist incident or a hazardous materials accident, for three reasons. First, decontamination is conducted to prevent the continual absorption of the chemical through the skin. Second, decontamination is essential in order to prevent the secondary contamination of emergency responders or hospital emergency department personnel. The secondary contamination can occur from off-gassing of chemicals on the victims body or clothing, or from the emergency responder touching contaminated parts of the victim. Third, decontamination can provide psychological comfort to victims—those contaminated, as well as those not.¹⁰⁹ Thus, decontamination is performed to help the victim, symptomatic or asymptomatic, as well as those who seek to assist the victim.

For the purposes of this dissertation there are two basic types of decontamination: Gross (sometimes called emergency) decontamination, and technical (also called field) decontamination.¹¹⁰

Gross decontamination. Gross decontamination involves the application of water to the potentially contaminated victims as quickly as possible. There are several methods to do this depending on the location of the incident, but it usually involves a fire engine using one or multiple

¹⁰⁷ Cox, Robert. "HazMat," *emedicine*, 2000. Internet: <http://www.emedicine.com/emerg/topic228.htm>

¹⁰⁸ U.S. Army Soldier and Biological Chemical Command (SBCCOM), *Guidelines for Mass Casualty Decontamination During a Terrorist Chemical Agent Incident*, January 2000, p. 4

¹⁰⁹ *Ibid.*

hoses to apply as much water as possible on as many victims as possible in a short period of time. This type of decontamination uses only water, and victims may only be in the spray of water for several seconds. The purpose is to provide high-volume dilution with water in the shortest amount of time, rather than to provide a thorough washing process.

Another part of the emergency or gross decontamination process is the removal of clothing prior to entry into the water spray. The careful removal of clothing (as much as the victim is willing to take off) can reduce the amount of contaminants on the victim by up to eighty percent.¹¹¹ The removal of clothing and quick gross decontamination may remove most of the contaminants.

Technical decontamination. Technical decontamination is used to more thoroughly remove the chemical contaminants off of the victims' bodies, and is more akin to showering than an emergency soaking by a fire hose. Technical decontamination requires field showers, or firefighters using handheld spray wands to provide a low-pressure spray of water that victims can use to wash themselves of the contaminants for a longer period of time—the time may depend on the number of casualties and the capability of decontamination equipment, but is recommended to be at least 3-5 minutes in length.¹¹² Soap is also provided to help in the decontamination process. Ambulatory victims are encouraged to perform this process themselves, while firefighters are trained to perform technical decontamination for victims who are non-ambulatory.

The effectiveness of these two decontamination methods depends in part on the chemical involved. For a highly volatile chemical in vapor form, such as hydrogen cyanide, phosgene, and chlorine, the removal of the outer clothing and gross decontamination should provide the basic decontamination needed to avoid secondary exposure.¹¹³ If the victim was exposed to the liquid form of any of the four chemicals, or the gas form of parathion, it is recommended that they receive technical

¹¹¹ Cox, Robert D. "Decontamination and Management of Hazardous Materials Exposure Victims in the Emergency Department," *Annals of Emergency Medicine*, 23:4, April 1994, p.761-770.

¹¹² Recommendation of Los Angeles County Disaster Physician.

decontamination. However, even the removal of the outer clothing and passing through gross decontamination should be of great benefit to those exposed to the liquid form of any of these four chemicals.

It is believed by some that the removal of the outer layer of clothing will reduce approximately 80% of the contamination,¹¹⁴ but there is little actual research to support to this assertion.¹¹⁵ Similarly there has been little research into determining the effectiveness of the various methods of decontamination. There have also been relatively few tests of the effectiveness of decontamination procedures on humans.¹¹⁶ This dissertation assumes the following concerning the use and effectiveness of decontamination: 1) Technical decontamination may not be necessary for all types of chemical exposures; 2) gross decontamination may be "good enough" for the decontamination of highly volatile vapors; and 3) technical decontamination is more effective for the removal of persistent chemicals than gross decontamination. Figure 4.1 presents the postulated effectiveness of the two types of decontamination for the chemicals examined in this dissertation.¹¹⁷ As shown in Figure 4.1, gross decontamination is effective for chemicals like chlorine, phosgene and hydrogen cyanide, and technical decontamination is effective for chemicals like parathion.

¹¹³ There is slight risk, if the victim was only exposed to the vapor/gas of the chemical and then removed to an area of fresh air, of the chemical causing further damage to the victim. However, for the sake of safety to the health care professionals, the victim should be decontaminated to ensure no secondary exposure.

¹¹⁴ Cox, Robert D. "Decontamination and management of hazardous materials exposure victims in the emergency department." *Annals of Emergency Medicine*, 23:4, (1994).

¹¹⁵ Barbara Muller Vogt and John H. Sorensen, "How clean is safe? Improving the effectiveness of decontamination of structures and people following chemical and biological incidents." Final Report. Oak Ridge National Laboratory. Oak Ridge, TN: October 2002. p. 22

¹¹⁶ A Swedish experiment used volunteers testing two types of decontamination methods (self-decontamination and a decontamination station) and simulants of chemical warfare agents. There was a reduction in the air concentration by a factor of 10,000 after the decontamination process. However, there was still a significant amount of chemical present in the air at the self-decontamination station, since one of the volunteers still had traces of chemicals in his/her underwear, see Muller Vogt and Sorensen, p. 22.

¹¹⁷ The curves represented in the figure were derived from discussion with medical and HazMat experts familiar with the characteristics of the chemicals.

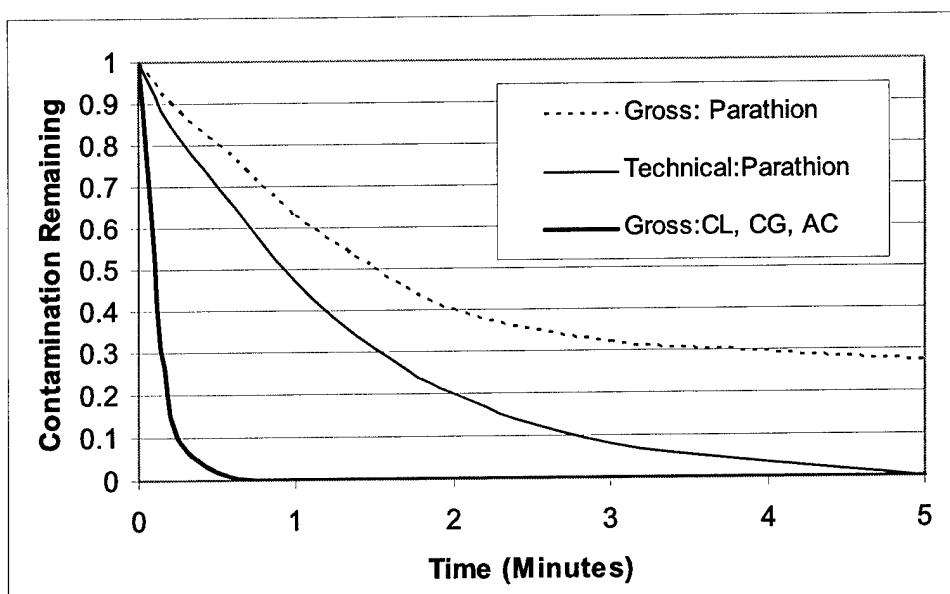


Figure 4.1 Postulated Effectiveness of Gross & Technical Decontamination for Selected Chemicals

We know that if victims are contaminated with a chemical agent, timely physical removal of the chemical is of primary importance to accomplish lifesaving decontamination procedures.¹¹⁸ What is still unknown is the rate of injuries sustained over time due to the delay in decontamination or medical services. Because chemicals cannot be tested on humans in the U.S., much of the data on the medical effects over time of chemical agents (including chlorine and phosgene) are from experiences in World War I.¹¹⁹ This dissertation estimates the value of decontamination and emergency medical services over time on the contaminated victims based on discussions with medical personnel with experience dealing with chemical exposure.¹²⁰ The assumption for this dissertation is that the probability of injury avoided is a function of the type of chemical and the response capability.¹²¹ These assumptions will be further discussed later in this chapter. However, in terms of response, time is

¹¹⁸ U.S. Army SBCCOM, *Guidelines for Cold weather Mass Decontamination During a Terrorist Chemical Agent Incident*, January 2002, p. 4.

¹¹⁹ Much of the World War I data on chemical injuries over time is anecdotal, based on small samples of soldiers. See Harry L. Gilchrist and Philip B. Matz, *The Residual Effects of Warfare Gases*, U.S. War Department, Washington, U.S. Government Printing Office, 1933 and Edward B. Vedder, *The Medical Aspects of Chemical Warfare*, Baltimore, Williams & Wilkins company, 1925.

¹²⁰ Discussions with three chemical medical experts (MDs) and one chemical exposure expert (Ph.D.).

¹²¹ The function is simplified and should include elements such as concentration of the chemical, exposure to the chemical, and weather. However, for this dissertation a simplified function is used. Further analysis could build upon this model.

critical (i.e., the shorter the time to respond the more likely casualties—whether death or injury—can be prevented). Figures 4.2 and 4.3 show the postulated value of decontamination for the chemicals of concern in terms of casualties avoided. These curves were created based on discussions with the aforementioned chemical experts. The experts were unsure of the exact relationship, but felt the curves in Figures 4.2 and 4.3 approximated adequately the possible avoidance of casualties based on response over time. Since exact data is not available for the creation of these curves, the dissertation uses a parametric approach by creating a range of probability of casualties avoided—a high probability of casualties avoided curve and a low probability of casualties avoided curve. The value of decontamination will be examined throughout the dissertation between these two levels.

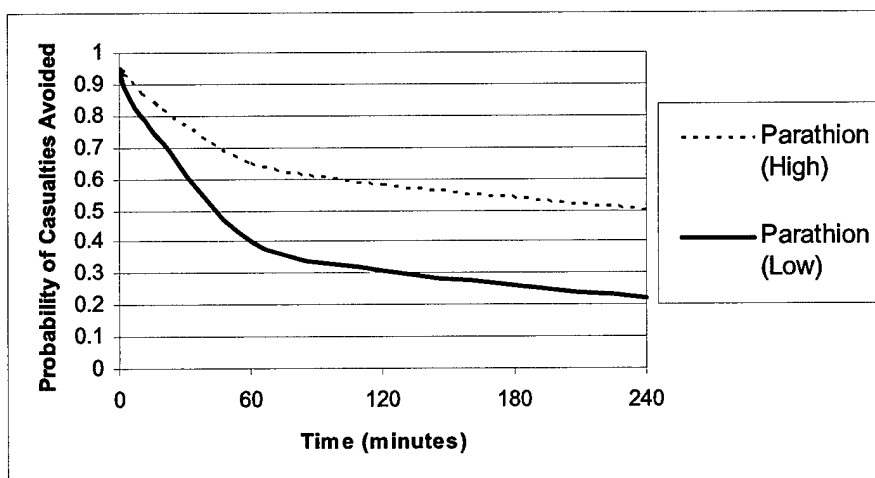


Figure 4.2 Postulated Values (High and Low) of Technical Decontamination in Terms of Casualties Avoided for Parathion¹²²

In Figure 4.2 the timely decontamination of victims helps stop the chemical parathion from causing further physiological damage to the victim (because the chemical left on the victim can be absorbed into the body to further poison the individual). With the other three chemicals, chlorine, phosgene, and hydrogen cyanide, there is little to no benefit of decontamination to prevent further casualties by removing the chemical (i.e., the damage caused by the chemical takes place at the initial exposure). However, the risk of secondary exposure may prevent these victims from obtaining

emergency medical services, whether on-scene by emergency responders or at hospitals by emergency department personnel. While the effects of chlorine and phosgene may not be manifest for a few hours, the delay in receiving medical services due to the need to mitigate the risk of secondary exposure can lead to victims suffering death or injuries. Figure 4.3 below postulates the probability of casualties avoided for chlorine, phosgene and hydrogen cyanide based on the time the victims receive medical services.¹²³

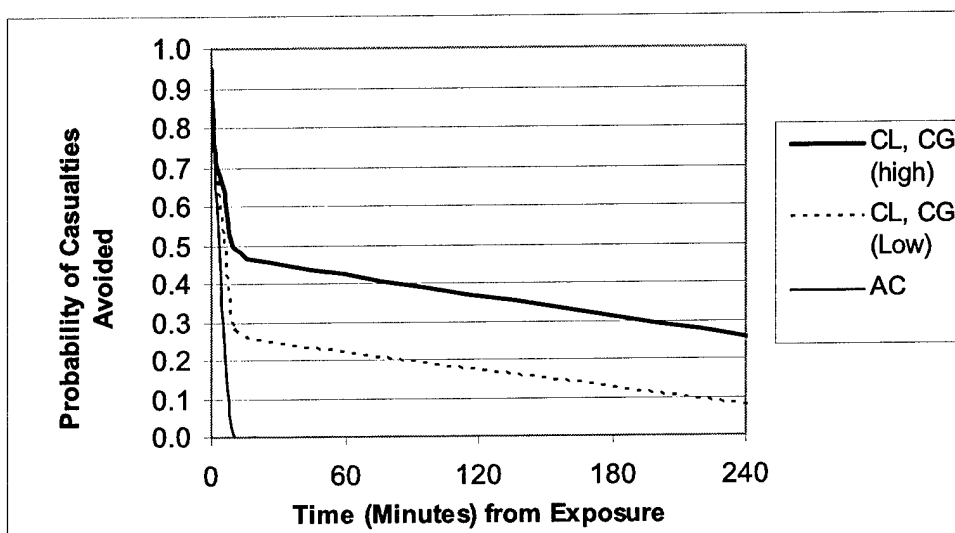


Figure 4.3 Postulated Value of Timely Medical Response in Terms of Lives Lost for Chlorine (CL), Phosgene (CG), and Hydrogen Cyanide (AC).

The required timeline may be too short for an effective response to a hydrogen cyanide attack (i.e., those who will die will do so relatively quickly and those who do not will survive), a delay in responsiveness is a deterrent of effectiveness to a chlorine or phosgene event could lead to injury or the loss of life. As can be seen from the previous figures, the chemicals chosen by the terrorists for their attack will play a role in the type of response needed and determine whether decontamination or timely medical response can assist in avoiding casualties.

¹²² The curves recommended by the experts take into account a brief gross decontamination at the beginning of the response process prior to the technical decontamination. The duration of the technical decontamination is assumed to be five minutes—the recommended duration according to current local policy.

¹²³ These curves are again based on the recommendation of several experts who agreed that in the absence of data the curves are an adequate representation of the characteristics of the chemicals over time. The delays in medical services may be a result of victims waiting for decontamination, or other delays such as traffic preventing the arrival of paramedics or congestion of victims arriving at hospitals.

Levels of Response Capabilities

As was explained in Chapter Two, there exist several performance levels for response that can be chosen *a priori* to implement based on any given casualty magnitude. For this chapter, these levels of performance have been categorized as low, medium and high.

A low-response performance level may reflect, in the case of chemical terrorism where time is critical, a decision 1) to respond with non-chemical terrorism specific equipment, training and organization; and 2) not to implement counter-chemical terrorism measures, such as decontamination. A decision to remain at a low level of response would reflect acceptance of many people possibly suffering either death or injury as a result. A medium-response performance level might reflect a modest level of improvement in equipment, training and/or organization, which would result in an improved response, but one that still results in preventable loss of life and injury. A high response would reflect a higher level of improvement in these areas. Although there might be death and injury, the high-level performance of response has the fewest avoidable consequences.

As the performance magnitude increases, in terms of casualties, so too will the capability to respond need to increase if the goal is to save lives and prevent injuries. As can be seen in Figure 4.4 below, with the capabilities fixed (one unit used in the response) as the number of victims increases the amount of time needed to perform decontamination also increases, regardless of what decontamination mechanism is used. The Mass Decontamination Unit (MDU)¹²⁴ provides the greatest decontamination in the least time (decontaminating 144 people per hour), while an inflatable tent decontamination system (listed as "tent") takes over twice the time for the same number of contaminated individuals (The tent system decontaminating at the rate of 60 people per hour). A single shower (with a rate of 12 people decontaminated per hour) at a single hospital would take the longest if

¹²⁴ More information on the MDU, as well as all the other response units, will be outlined in a subsequent section of this chapter.

it alone was used to decontaminate all the victims.¹²⁵ While each system can decontaminate the same number of people, clearly some systems operate at a higher performance level.

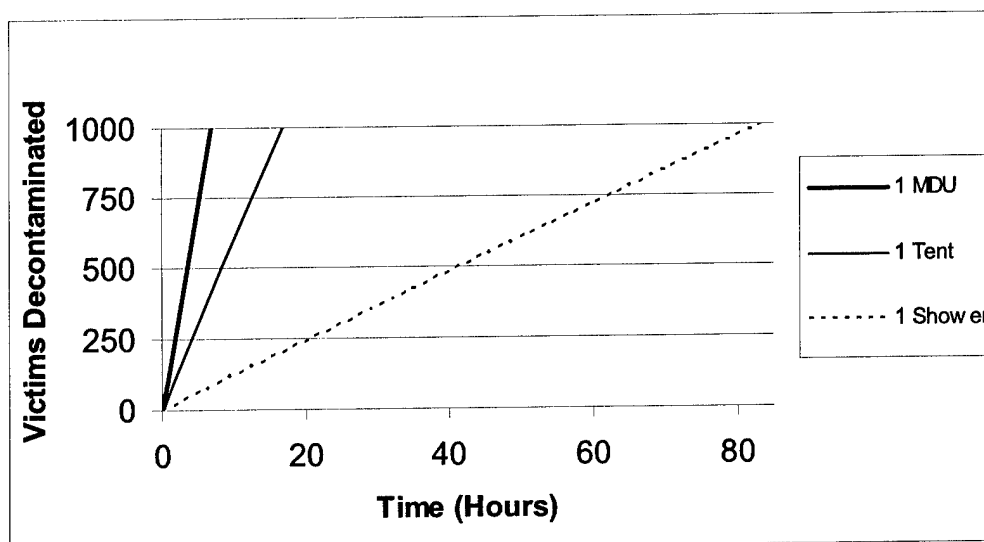


Figure 4.4 Magnitude (Number of Victims Requiring Technical Decontamination) Drives Capability; Capabilities Fixed

The capability to respond to a given magnitude is not dependent only on the number of units responding to the event. The capability of the units is defined by the responsiveness (the time which they can arrive on the scene), the time to set up the equipment and the time to assist in decontaminating the individual victims. The first variable, response rate, could be modified by changes in location of the equipment, the mode of transportation, or the readiness of the equipment for movement. The latter two variables, set-up time and decontamination time, can be affected by organization or training. The notional impact of various changes is shown in Figure 4.5 below.

¹²⁵ The decontamination rates of these three units as well as all statistics used in the dissertation pertaining to decontamination equipment were derived from exercises conducted in Los Angeles, based on normal performance and with each individual in the technical decontamination showering process for five minutes.

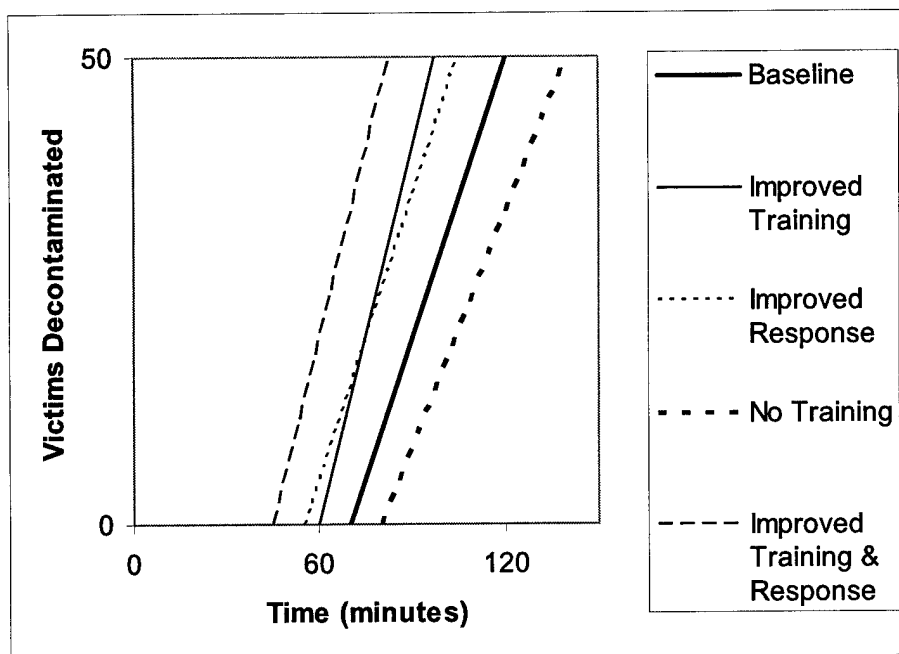


Figure 4.5 Notional Changes in Capability through Improvements or Lack of Training and Response

In Figure 4.5 the baseline represents the planned rate for technical decontamination of 1 to 50 victims using one of the tent systems based on statistics from past live exercises under the assumption that the victims take five minutes in the decontamination showering process. The time on the x-axis shows that approximately 70 minutes transpire before the system is operational. This is due to the arrival and setup time of the system. If improvements in response to the scene were implemented, the results would reflect a new line parallel to the baseline, with all the victims decontaminated earlier (for the purpose of the above example a notional fifteen minute response improvement is shown). An improvement in training for example could decrease the setup time and decrease the time required for each victim to be decontaminated, since better-trained firefighters manning the system ostensibly would be more effective. This is shown by a reduction in the start time (shown above as a notional reduction in ten minutes to start) and an overall notional improvement throughout the whole process; thus the start for the line moves left by ten minutes and the line becomes steeper. A notional improvement in both response and training would cause a further reduction in time to start the decontamination process, and would decrease the time per person—shown by the line moving to the

left and steeper than baseline. On the other hand, a notional lack of training would cause a degradation of the firefighters' ability to set up and decontaminate victims, causing the line in the figure to move right of and be less steep as the baseline.

Los Angeles Chemical Terrorism Response Units

The Los Angeles metropolitan area has a number of available units that can be used in response to a chemical terrorist incident. While some of these units are owned and operated by single agencies, such as LAFD or LACoFD, through mutual aid agreements these resources can be brought in to assist other agencies at larger incidents if requested.

Hazardous Material (HAZMAT) teams—There are 14 HazMat teams (LAFD, LACoFD, and other LA County communities' fire departments) in Los Angeles county that could respond to a chemical terrorist incident. Their primary mission is the detection and neutralization of the hazardous material. In a chemical terrorism attack, the HazMat unit would attempt to identify the chemical used by the terrorists in order to improve response.¹²⁶ If the source used by the terrorists was still discharging the chemical agent, the HazMat team would try to contain the device in order to stop further contamination. These are the primary functions that HazMat teams perform on a daily basis in responding to hazardous materials incidents caused by accident rather than intentionally by terrorists. The HazMat teams do on a regular basis decontaminate themselves after exposure to chemicals, as well as small numbers of exposed victims in chemical accidents. While HazMat team members are certified emergency medical technicians, medical treatment is routinely left to paramedics or to medical personnel at hospitals.

¹²⁶ Discussions with HazMat operators in Los Angeles County led to the consensus that the HazMat units have the capability to detect and identify the four chemicals discussed in the dissertation but with varying times depending on the chemical.

According to the LACoFD Mass Casualty Mass Decontamination (MCMD) plan,¹²⁷ in a small chemical terrorist attack—an attack with relatively few contaminated victims (1 to 10)—the HazMat team has the primary task of decontaminating the victims. In larger attacks—those with more than ten contaminated victims—the role of the HazMat team is not to decontaminate victims, but to decontaminate emergency personnel as they leave the “hot zone.” The incident commander at the scene would make the determination of the size and mission of the HazMat team based on the size of the incident.

The HazMat team uses the “kiddie pool” system to decontaminate personnel. Three plastic pools, similar to children’s pools, are laid in a row and the contaminated persons stand in the first pool while sprayed with water and soap or bleach mixtures. The pool collects the runoff water.¹²⁸ The person being decontaminated then takes a step into the next two pools and the process is repeated. The baseline capabilities of this method can be seen in Figure 4.6 below, based on a notional 20-minute arrival time and 10-minute set-up time and a technical decontamination rate of 12 people per hour.

¹²⁷ See The InterAgency Board for Equipment Standardization and InterOperability, *2000 Annual Report*, April 2001. The MCMD plan was created in preparation for the 2000 Democratic National Convention that took place in Los Angeles.

¹²⁸ The collection of contaminated runoff in “kiddie pools” is required by state and federal environmental guidelines for routine HazMat incidents where there is no, or little threat, to human life or injury. In the case of a mass casualty incident or where the potential for the loss of life or injury is great the environmental protection aspects, such as the collection of runoff is a secondary concern. “The goal is to remove the threatening contaminant as quickly as possible. There is no regard for the environment or property.” Michael Wieder, ed. et al, *“Hazardous Materials for First Responders,”* Second Edition. Stillwater, OK: Fire Protection Publications, 1994, p. 209.

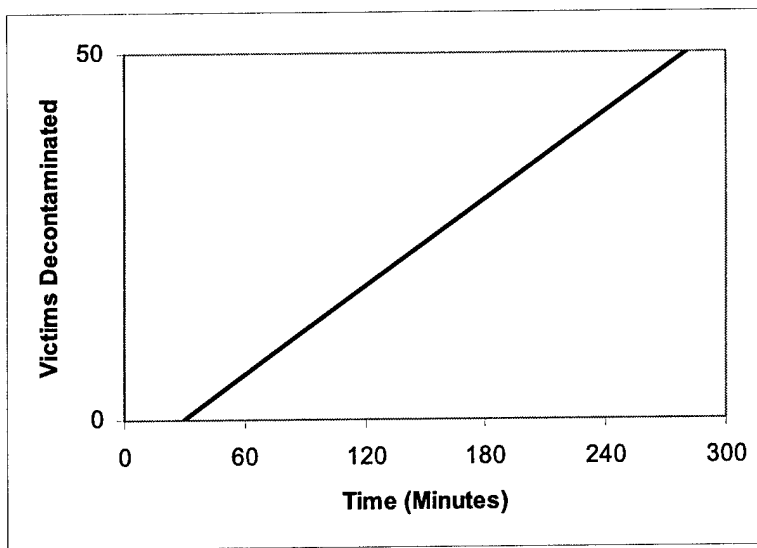


Figure 4.6 Baseline Technical Decontamination Capabilities of a Single HazMat Unit

Typically one individual is decontaminated at a time through the system, but up to three—one per pool—could be done simultaneously. There is no additional training necessary for this process, since this is standard procedure for all HazMat teams, and is used on a regular basis.

Mass Decontamination Inflatable Tent system—This system, owned by LACoFD, is comprised of five inflatable tents that link to provide for modesty while victims go through the decontamination process. Two interlinked tents are for male victims, another two for female, and one with a roller system is used for non-ambulatory victims. Four firefighters (for a total of 12) are stationed within each portion (male, female and non-ambulatory) to assist with the decontamination process—two in each portion use shower wands. Eight additional firefighters (part of the five engine strike team detailed below) assist and rotate as needed. The victims enter the appropriate tent, strip off their clothing, are decontaminated through use of shower wands and then are given a hospital gown or jumper for modesty before stepping out away from the tent.

This system allows for more victims to be simultaneously decontaminated than can be done by a HazMat team, yet is labor intensive since two firefighters are needed for each ambulatory victim being decontaminated at any given time in the process, and four firefighters for each non-ambulatory victim.

The system can be set up in approximately twenty minutes. Firefighters need to be trained on how to set up the system and how to decontaminate the victims. This is not a process that is used on a regular basis, like decontamination is for HazMat teams, so without recurring training, the skills and knowledge necessary to optimally run the Mass Decontamination Inflatable Tent System deteriorate. A fire strike team, comprised of five fire engine companies, operates the tent system. The baseline performance for the tent system can be seen in Figure 4.7 below, based on a notional 50-minute wait for the equipment to arrive and with a decontamination rate of 60 people per hour.¹²⁹ The notionally slow response rate is due to there being a single centrally located cache of tent system equipment, which must be taken to the incident site anywhere within the entire county.

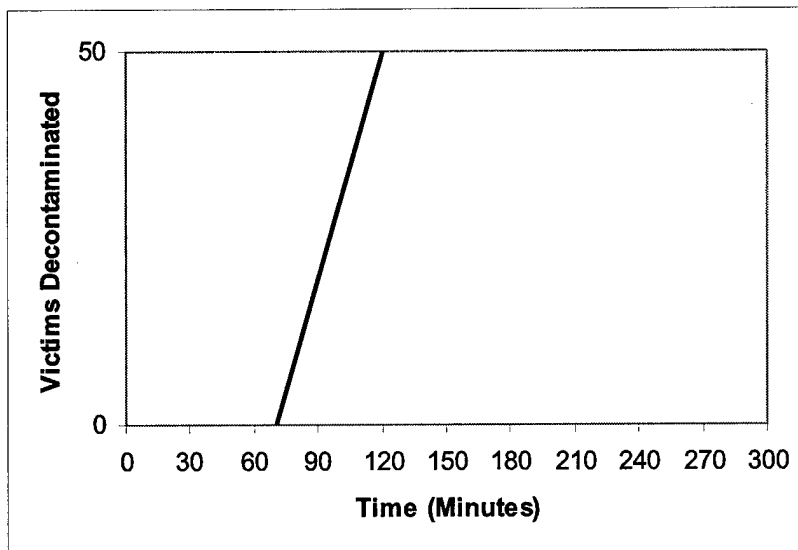


Figure 4.7 Baseline Strike Team Tent Decontamination Capabilities

Mass Decontamination Unit (MDU)—the greater Los Angeles area has three of these trailers. Two are operated by the Los Angeles City Fire Department and located at Los Angeles International Airport (LAX) and the third is at Ontario Airport. Of all the resources in the Los Angeles area, these trailers provide the highest decontamination throughput. The trailer itself has showers inside for decontamination, to be used by emergency personnel to decontaminate one another, or

¹²⁹ The time for arrival is based on discussions with senior response personnel familiar with the location of the equipment and the average time to key locations within the County. This time is notional, and various times due to shorter or longer distances and average or heavy traffic will be explored in Chapter Five.

combined with a roller system to decontaminate non-ambulatory victims. On either side of the trailer, multiple shower booms can be folded out to provide simultaneous decontamination. An awning-like tent on each side provides a degree of modesty. A picture of the MDU can be seen in Figure 4.8 below. Like the tent system, one side would be used for male victims and the other for female, with victims stripping their remaining clothing at the front of the tent and putting on hospital gowns after the decontamination process is complete. However, unlike the tent system, the trailer needs fewer personnel since ambulatory victims can decontaminate themselves under stationary shower spigots.

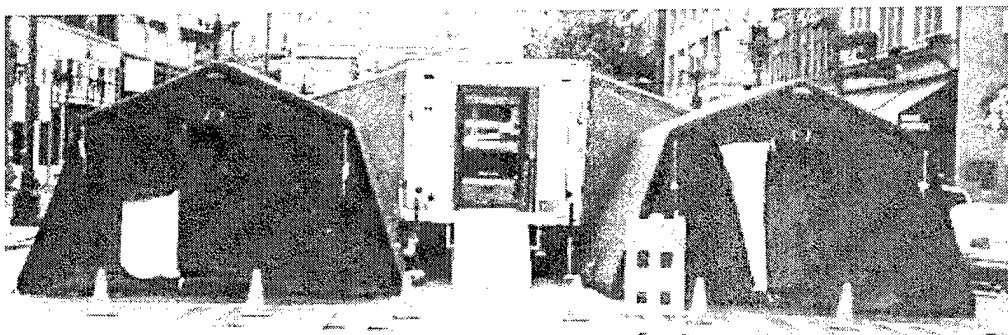


Figure 4.8 Deployed Mass Decontamination Unit

These trailers belong to the Los Angeles World Airports, but are manned by Los Angeles City firefighters. If a large incident occurred away from the airport, the MDUs could be moved to the site by the firefighters. Trained firefighters can set up the system in approximately twenty minutes after arrival. However, not all city firefighters have been trained to set the system up, just those who provide fire service at the airports. Like the tent system, continual training is needed to maintain the knowledge and skills necessary to set up and run the MDU, since it is not part of the day-to-day activities of the firefighters. The MDU's baseline capabilities, represented by a slope based on 144 people decontaminated per hour and a notional 45-minute arrival time, plus a 20-minute setup time, can be seen in Figure 4.9 below.¹³⁰

¹³⁰ The 45-minute arrival time was derived from discussions from senior response personnel based on time to

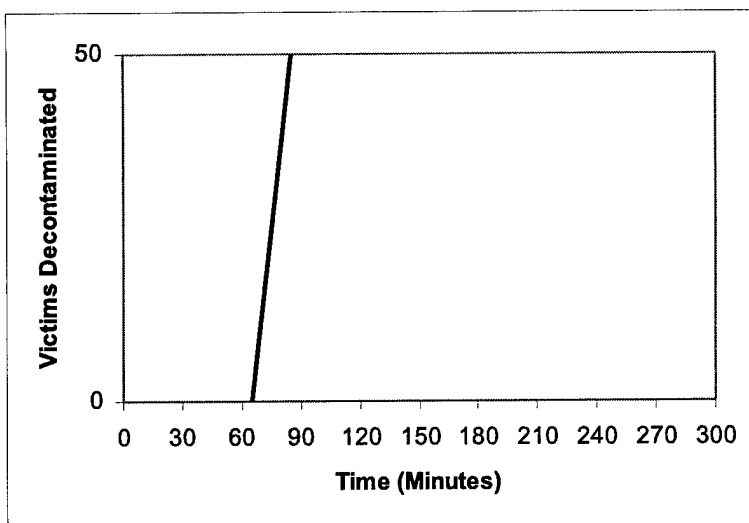


Figure 4.9 Notional Baseline Mass Decontamination Unit Technical Decontamination Capabilities

Fire Company—All firefighters in the Los Angeles County and City fire departments have been trained in mass decontamination procedures. The basic unit of firefighters, the fire company, works as a team at a mass decontamination site. Between LAFD and LACoFD there are 340 fire companies. They have been trained, if arriving first at the scene, to provide an initial assessment and report back to dispatch. They all have been taught to provide gross decontamination as soon as possible. The basic throughput of gross decontamination, based on recent exercises, is 800 individuals per hour. With training, fire companies can also assist other mass decontamination units in providing technical decontamination.

Paramedic—All firefighters in LACoFD and LAFD, as well as in all the county's other fire departments, are trained emergency medical technicians (EMT). However, both LACoFD and LAFD also have trained paramedics on their staff: LACoFD has approximately 800 and LAFD has approximately 600. Paramedics have a greater medical proficiency and receive additional medical training throughout the year than basic EMTs. The paramedics travel in either LAFD's 65 two-person ambulances or LACoFD's 79 three-person squad trucks. In a response to chemical terrorism these additionally medically trained fire personnel are to perform triage before victims go through technical decontamination, and to perform emergency medical procedures if warranted (administer antidotes,

ventilation, oxygen, etc.). These medical services provided by the paramedics are to stabilize victims prior to being sent on to hospitals for further medical treatment if needed.

Hospitals—Each hospital is required by the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) to have, at minimum, the ability to decontaminate one person. Often this is fulfilled by having a shower located within the hospital, at times with easy access to the outside. However, a single hose attached to an outside spigot could also fulfill the same JCAHO requirement. In the year 2000 most hospitals in the downtown Los Angeles area prepared for the Democratic National Convention by training personnel to wear protective equipment and to operate their decontamination equipment. Currently most hospitals in Los Angeles are considering creating permanent decontamination facilities for multiple victims on the outside of the hospital, but are fighting environmental obstacles due to the need to manage contaminated runoff water. Some of the hospitals have portable shower systems that can be erected outside in approximately 15 to 20 minutes. The use of these portable devices, as well as donning personal protective equipment (PPE) requires additional training for hospital personnel and is not part of normal activities. Even if the hospital used an existing internal shower, the assisting personnel would still need time to set up—donning PPE, evacuating others near the shower, etc. The baseline capabilities based on a single hospital with a single shower (following the JCAHO guidelines) are shown in Figure 4.10 below, based on a 20 minute set-up time after the first victims arrive (the first victims are assumed in this figure to arrive approximately 10 minutes after the incident)¹³¹ and a five minute per person time in the shower.¹³²

¹³¹ The notional ten minute arrival time for the first victims was derived from discussions with senior responder and hospital personnel.

¹³² The five minute time in the shower is based on recommendations by the Los Angeles Department of Health Services to the county hospitals. Times could vary depending on the type of chemical and the amount of victims waiting on decontamination.

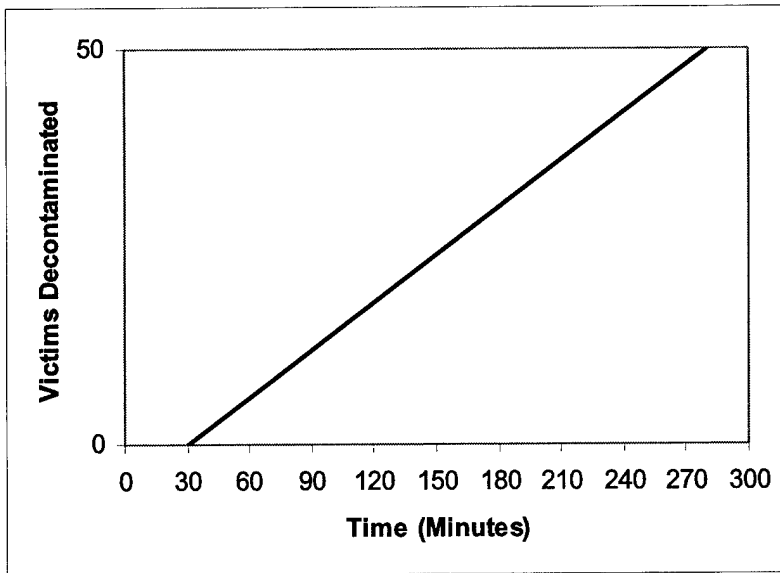


Figure 4.10 Baseline (Single) Hospital Shower Decontamination Capability

While JCAHO may only require the capability to decontaminate a single individual, some hospitals in Los Angeles are acknowledging the potential need to decontaminate multiple casualties, which may require additional shower facilities. Figure 4.11 below shows how additional showers at the hospital can significantly reduce the amount of time for decontamination compared to the minimum, mandated capability.

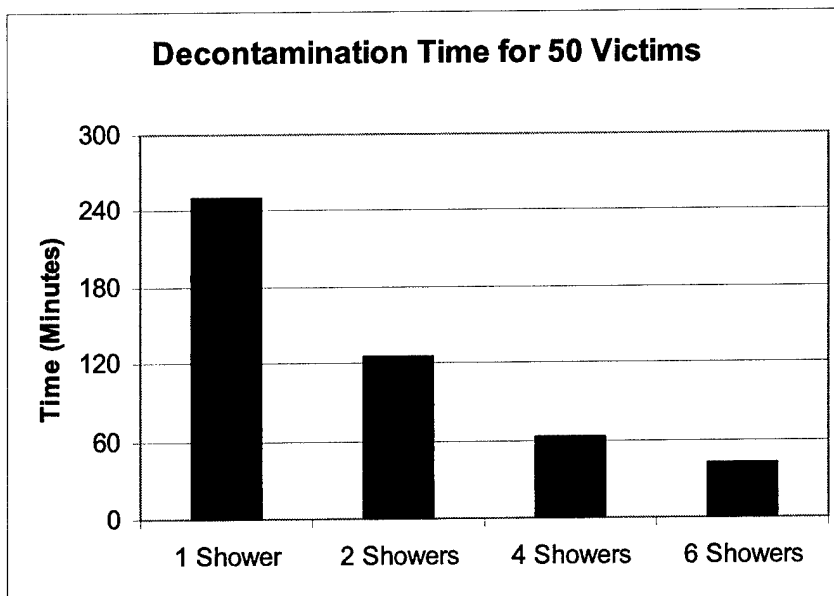


Figure 4.11 Time After Set-Up to Complete Decontamination for Varying Number of Hospital Showers

National Guard Weapons of Mass Destruction-Civil Support Team

The U.S. Army National Guard maintains a Weapons of Mass Destruction – Civil Support Team (WMD-CST) at the U.S. Army Training Support Center in Los Alamitos—a city in Orange County. The WMD-CST, formerly known as the Rapid Assessment and Initial Detection Team, is a 22-person unit of full-time National Guardsmen who are specialized in the assessment of chemical warfare agents. The Los Alamitos WMD-CST is one of 27 such units across the country that is to provide advice and support to civilian emergency responders and the medical community in times of a WMD attack; more WMD-CSTs are being created.¹³³

The WMD-CST in Los Alamitos is a certified unit, and has participated with the Los Angeles responder community in training and at TEW meetings. However, their utility in responding to a chemical terrorist event is questionable. Time of arrival to the chemical terrorism scene is critical if the team is to provide support, yet the WMD-CST units' goal is to be ready for *departure* to the scene within four hours of notification. Even if the time was cut in half, and the time to the scene was added, the WMD-CST in the Los Angeles area might not arrive at the scene until three hours after the incident

began.¹³⁴ A smaller group of individuals from the team may be able to arrive sooner, but they will still arrive well after the local fire, law enforcement, and HazMat units.

Once the WMD-CST personnel do arrive at the scene, they will be able to provide recommendations to the incident commander. Using their specialized equipment, the team could provide a determination of the chemical or chemicals used in the attack, but the HazMat team should have already provided this information by the time the WMD-CST arrive. The WMD-CST have more specialized equipment than HazMat teams, but the equipment of the HazMat teams can detect and identify most TICs. While the WMD-CST is trained in decontamination, it is used to support their own personnel, and like a standard HazMat team, they are not equipped to provide mass gross or technical decontamination. Similarly, the team has medical personnel, but this is to provide advice and recommendations to on-site commanders, and not to provide on-scene medical service to the victims of the attack.

Comparison of Units

Each of the units described above brings its own particular response strengths and weaknesses to a chemical terrorist event. As can be seen in Table 4.2 below, the units can be differentiated by their abilities to provide chemical detection, mass decontamination, and medical services. None of the groups provides all of these services by themselves, and therefore they rely on cooperation to fully and effectively respond to an incident (e.g., HazMat units detect and assess the chemical and mitigate the device, while a fire strike team will provide decontamination and basic medical services before sending victims on to hospitals for further medical treatment.). The units who have medical capabilities also provide varying levels of services. Firefighters (in an individual company or strike team) are mainly emergency medical technicians (EMT), which is the lowest level of medical responder. They can provide oxygen, and perform emergency first aid, if required. Paramedics

¹³³ Plans are for 54 WMD-CST units around the country.

(arriving in ambulances or attached to some of the fire companies) have more training than EMTs and can perform triage, administer antidotes, and deliver other emergency medical services. The hospitals, with the nurses and physicians, can perform a full range of medical services.

Unit	Identification	Gross Decon	Technical Decon	Medical Services
Fire Engine Company		x	x	x
Strike Team		x	x	x
Paramedics				x
HazMat Units	x		x	
MDU			x	
Hospitals			x	x
WMD/CST	x		x*	x†

* Provides decontamination for own personnel.

† Medical personnel provide advice to incident commander.

Table 4.2 Capabilities of Various Chemical Terrorism Responding Units

Figure 4.12 below shows each of the above-mentioned technical decontamination units (Tent Decontamination Unit, Mass Decontamination Unit, HazMat teams and Hospital shower) together in one chart. As can be seen, the tent system and MDU have a greater capability to decontaminate mass casualties in less time than do the HazMat unit or a single hospital shower. Although victims would be able to arrive at a hospital, or have the HazMat unit arrive and set up sooner than it might take the tent system or MDU to arrive and set up, in the long-run, the specialized decontamination units (i.e., tent unit and MDU) provide faster service for multiple victims. However, Figure 4.12 assumes only one single unit of each type of response unit. In an actual chemical terrorist incident, more than one unit may be needed. Table 4.3 below shows how many of each type of unit (excluding HazMat units) would be needed to decontaminate 100, 500, or 1,000 victims within 90 minutes, 180 minutes, or 360 minutes if they operated independently of the other units. However, as will be seen in the scenario described the next section, these units do not operate alone.

¹³⁴ Any of the previously described units and the WMD-CST could be pre-deployed, that is brought to the scene prior to a chemical terrorist incident, should intelligence warnings indicate a need to set up the capability elsewhere. Units could be pre-deployed at special events where there is a high threat. However, this dissertation does not explore pre-deployment, since decision makers cannot always count on intelligence to accurately predict the exact time and location of an attack..

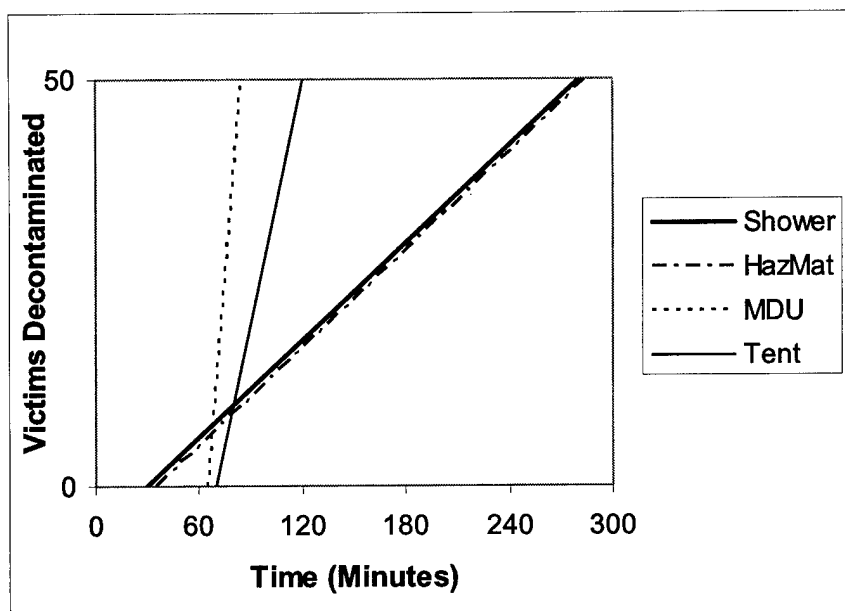


Figure 4.12 Baseline Capabilities for All Decontamination Units

	High (90 Minutes)				Medium (180 Minutes)				Low (360 Minutes)			
Victims	MDU	Tent	HazMat	Shower	MDU	Tent	HazMat	Shower	MDU	Tent	HazMat	Shower
100	1	1	6	6	1	1	3	3	1	1	1	1
500	2	6	28	28	1	3	14	14	1	1	7	7
1000	4	11	56	56	2	6	28	28	1	3	14	14

Table 4.3 Units Required for Response, Acting Alone by Type¹³⁵

Baseline Scenario: Chemical Terrorist Attack and Response in Los Angeles

The following scenario illustrates how a response may be orchestrated to a chemical terrorist event. The scenario represents the current equipment and policies of the responder community.¹³⁶ The scenario makes the assumption that the attack takes place in the jurisdiction of either the LAFD or LACoFD, and that the two fire departments call on each other through mutual aid agreements for

¹³⁵ This table represents a simple calculation and does not include arrival or set up time, rather it is merely a representation of how more capabilities are demanded as magnitude rises. The number of response equipment have been rounded up, since it is impossible to have a fraction of a piece of equipment, and at a minimum one piece of equipment is needed.

assistance. The times listed are notional, but are based on discussions with senior responder and medical personnel.

Timeline

[0:00] A chemical terrorist event takes place. The chemical release might have been disseminated among the victims by an explosion, via a liquid spray, or a dissemination of gas in the air. Regardless, many people are exposed to the chemical, and depending on the chemical used, many are having a difficult time breathing and some victims seem to have succumbed to the chemical and are lying on the ground.

[0:01] The 911 dispatcher receives a call—there has been an apparent accident and a chemical gas has been released in a crowded area. The dispatcher contacts the closest fire company and HazMat unit and dispatches them to the scene. The dispatcher also contacts law enforcement to assist in evacuation and perimeter control.

[0:06] The first fire company arrives five minutes after dispatch receives the call and evaluates the scene. The company is already in their standard turnout gear and wearing their self-contained breathing apparatus (SCBA). There are many people trying to leave the incident site (presumably going to nearby hospitals), yet a large body of people has stayed at the scene. The company sees mostly ambulatory victims, but also sees people on the ground, some in states of convulsion, while others lie still. Other victims are visibly trying to gain their breath. The fire company quickly calls back to headquarters and informs them of the situation and requests that the multi-casualty mass decontamination plan be implemented (the first fire company would estimate the number of victims and determine the proper number of responders needed to decontaminate the on-scene victims). The fire

¹³⁶ The scenario follows basic assumptions and policies represented by current guidelines outlined in the Multi-Casualty Mass Decontamination program of the Los Angeles County Fire Department, and the similar policies of the Los Angeles Fire Department. This information was assembled through numerous interviews of members of the response community and from Ron D. Watson, "County of Los Angeles Fire Department Multi-Casualty Mass Decontamination Plan for the 2000 Democratic National Convention," in The InterAgency Board for Equipment Standardization and InterOperability 2000 Annual Report, April 2001.

company, however, does not attempt to enter into the hot zone, rather allowing the HazMat unit, which is better equipped, to do so when it arrives.

[0:10] The first fire company opens up their hoses to start performing gross decontamination and uses a loud-speaker to request that all those who can walk start approaching the fire engine to begin the process of washing the chemicals off their bodies. The firefighter on the loudspeaker also tells the victims that more help is on the way and that their first priority is to decontaminate themselves and receive medical attention. Those ambulatory victims on scene proceed to the fire engine and are drenched with the water from the fire hose.¹³⁷ The ambulatory victims are also told to shed as much clothing as possible to get remaining chemicals off their bodies. Depending where the non-ambulatory victims might be, the firefighters may be able to spray them down with their hoses as well. The ambulatory victims then are instructed to assemble themselves and wait for the additional rescue workers to arrive. They are directed to gather upwind from the incident.

During this time, the HazMat team is still approaching the scene, while the multiple fire companies comprising the strike team assemble in a close-by staging area—upwind from the incident. Meanwhile, victims of the attack who left the incident area seeking out medical attention begin arriving at area hospitals—such individuals are termed “convergent casualties.”¹³⁸ Convergent casualties will not all go to the same hospital. Rather, they will travel to an assortment of closest hospitals and medical care facilities most familiar to them. The contaminated casualties may reach area hospitals before or at the same time the hospitals are notified by dispatch that contaminated casualties may be on their way. Without prior notification and/or quick reactions, these emergency departments could themselves become contaminated if they are not ready to triage the patients outside the ED. The process at the hospital make take at least 15 to 20 minutes to prepare before starting the technical

¹³⁷ Gross decontamination can take 15 to 60 seconds depending on the number of victims and number of engines providing the gross decontamination. A longer period is preferable in order to initially wash off as much chemical as possible, however a backlog in people may limit the time spent in gross decontamination.

decontamination process for hospital personnel to locate and don PPE and get the temporary decontamination shower set up for service.

[0:15] The first strike team (comprising five fire companies), having arrived at the scene, don their personal protective equipment, and assist the first fire company in providing gross decontamination and crowd control. However, their equipment to provide technical decontamination is still on its way to the scene. Arriving paramedics provide initial medical triage to prioritize the medical services, including technical decontamination, according to victim needs.

[0:20] The first HazMat team arrives on the scene and likewise don their personal protective equipment. The team will go into the hot zone to provide an initial assessment of the scene, see if mitigation of the chemical (i.e., to stop the continuation of chemical release) is necessary, and if necessary, do so. Other members start the process of identifying the chemical(s) used in the incident—a process that can take 30-60 minutes. The remaining members of the unit will set up their decontamination equipment (they will be using the “kiddie pool” system), an additional fifteen-minute process. This decontamination area will be used for technical decontaminating the emergency responders, including members of the HazMat unit. However, as noted above, in an incident with fewer than ten victims, the HazMat team would be the primary unit to perform technical decontamination.

[0:25] A second fire strike team has arrived at the scene. They too will put on their personal protective equipment and assist in triage. Meanwhile, at the hospitals, designated trained personnel set up the hospital's decontamination equipment and assist the victims. A triage process at the hospitals and on-scene determines who is decontaminated first. In Los Angeles most hospitals have been trained in mass casualty decontamination, and have plans for building additional decontamination facilities, but most still only have one or two shower systems. The decontamination process begins and

¹³⁸ In the March 1995 Tokyo sarin gas incident between seventy and eighty percent of the casualties traveled on their own to hospitals. This percentage is typical of many mass casualty incidents, such as the Oklahoma City bombing in 1994 where hundreds of patients brought themselves to nearby hospitals; see National Memorial

continues until all the victims are decontaminated¹³⁹ and screened by hospital personnel for medical treatment.

[0:55] If needed, the strike teams' mass decontamination equipment now arrives (both the tent systems and Mass Decontamination Unit would arrive approximately at the same time, depending on the location of the incident), and the first two strike teams now start to assemble the equipment. Both the five-tent system and the MDU can process male and female victims concurrently while providing some privacy, as well as a decontamination system for non-ambulatory victims—each of these systems will take another twenty minutes to be properly set up.

[1:15] By this time the HazMat unit has identified the chemical(s) and recommends to the incident commander whether technical decontamination is necessary. The mass decontamination equipment is now ready to be used. Regardless of what system is used to technically decontaminate the victims, they are triaged again after decontamination and given medical attention in the cold zone. If necessary, they are then transported individually (i.e. via ambulance) or en masse (i.e. via buses¹⁴⁰) to designated hospitals for further medical treatment.

[2:00-5:00] The National Guard WMD-CST might arrive two to five hours after the incident started to assist in the response efforts. A small advance element of the WMD-CST may be able to leave its base quickly and arrive after two hours, but the standard doctrine for all WMD-CST units is to be ready for deployment after 4 hours. Thus, the response time is dependent on how soon the WMD-CST could mobilize and get to the scene. The team might assist in offering technical assistance in the identification of the chemical, if the HazMat team has not already done so, or suggesting medical

Institute for the Prevention of Terrorism, *Oklahoma City Seven Years Later: Lessons for Other Communities*, 2002. Internet: <http://www.mipt.org/pdf/MIPT-OKC7YearsLater.pdf>.

¹³⁹ Decontamination, depending on the chemical, may be complete after gross decontamination or after technical decontamination. For this timeline it is assumed that the chemical exposure requires technical decontamination. However, even after the decontamination process, the victims would be held for observation.

services for the casualties. However, by the time the WMD-CST arrives, the identification most likely has already been done by the first HazMat team to arrive as indicated above.

Scenario Conclusion

The level of response is dependent upon the size of the incident, number of casualties, and type of chemical used. However, with a planning magnitude of 1,000 victims, the time from the incident itself until all victims have been decontaminated and received initial medical attention using the baseline system at the incident site should be a matter of 3 to 5 hours.¹⁴¹ Within this time, regional, state or federal resources generally cannot reach the site and take part in this initial phase of the response. The first units to respond are the local responders (fire, law enforcement, HazMat, emergency medical, and perhaps local responders from nearby communities in the form of mutual aid).¹⁴² As time progresses, and if the magnitude of the disaster necessitated it, state units (e.g., WMD-CST) would be available, as well as federal units. However, the response to the incident—in terms of saving lives or reducing damage at the scene—may be finished before many of those state and federal resources could arrive. These resources may be most beneficial in the clean-up of the incident site. We now turn to ways in which the baseline can be improved.

Chemical Terrorism Planning model

Servicemodel 2002 is the modeling software used for this dissertation to simulate the response to a chemical terrorist attack and subsequent triage and decontamination by the entities mentioned

¹⁴⁰ In a chemical incident with relatively small number of victims, ambulances could quickly transport the decontaminated individuals to hospitals. However in an incident with numerous victims, the quickest way to transport victims to hospitals after decontamination is via buses. These buses can take the lower risk/ambulatory victims to the area hospitals, while allowing ambulances to take the higher risk/non-ambulatory victims. The buses can belong to either the public safety departments (e.g., use the LASD buses used to transport prisoners) or use mass transit buses commandeered for this specific use.

¹⁴¹ Reduction of this time is one of the goals of this dissertation.

¹⁴² Nearly all jurisdictions throughout the nation have signed mutual aid agreements promising to support disaster responses that tax the capability of their neighboring communities. Large fires, or criminal activities, bring resources from outside the community on a regular basis. The City of Los Angeles and the County of Los Angeles have mutual aid agreements with each other and other communities within the metropolitan area. In the case of a chemical attack in Los Angeles area, the LAFD could provide the MDU resources to the County, and the County can provide the tent decontamination units to the city through mutual aid.

earlier in the chapter (strike teams, MDUs, HazMat units, hospitals, etc.). The software enables visual representations of an incident as it takes place, assisting in the validation of the model.¹⁴³ The simulation models the arrival and setup time of response units, the travel of convergent casualties to area hospitals, as well as the approximate time to process victims through triage and decontamination. The rudimentary modeling presented so far in this dissertation has included the response entities operating independently and thus did not reflect the interaction of the units working together, nor did it represent the arrival and set-up time of multiple units over time.

The planning model conceptually represented elements of a chemical response found in chemical exposure scenarios, whether a chemical terrorist incident or a large chemical spill. In addition to allowing the user to visualize the simulation and its components, the software also provides the ability for data manipulation and analysis. The Servicemodel software has been used elsewhere for other terrorism-related simulations, such as modeling the inspection of baggage at John F. Kennedy Airport in New York City, and modeling the security checkpoints at the 2002 Winter Olympics in Salt Lake City.

Data

The model was based on data collected from the response units of the LAFD, LACoFD, LA DHS, and LA World Airports. Since the Los Angeles community has not responded to an actual incident of chemical terrorism, the data was based on live exercises the responding agencies in Los Angeles have conducted in the past several years using the equipment represented in the model. These exercises include the large-scale exercise entitled "Westwind," held in 1999, as well as training exercises held in preparation for the 2000 Democratic National Convention and continuing annual training.

¹⁴³ Terrorism coordinators from LAFD and LACoFD, as well as other TEW members, have reviewed the visualization component of the model to ensure that the model reflects a simplified, but faithful representation of a chemical terrorist incident response.

The various decontamination times are the same as those used in the unit descriptions above. These times are based on the responses claimed by the responding agencies backed up by live exercises. While data was not collected on each individual going through the decontamination process during the live exercises, the average decontamination times were collected. The data used in the model is based on these averages.

Chemical Terrorism Planning model

The emergency response represented by the chemical terrorism planning model encompasses the arrival, setup, triage, decontamination and emergency medical services at the incident scene and the setup, triage and decontamination at area hospitals.¹⁴⁴ The model seeks to identify problems with and potential improvements to the current baseline capabilities, as well as to simulate the effects of potential cost-effective options. A flow chart of the model is shown below in Figure 4.13.

¹⁴⁴ The medical services at the hospitals are provided within the emergency room after the victims have been decontaminated or it has been determined that they no longer are contaminated (should they be decontaminated on-scene first or the chemical no longer poses a threat to the hospital health care personnel). The actions taken within the hospital emergency room are outside the scope of this dissertation.

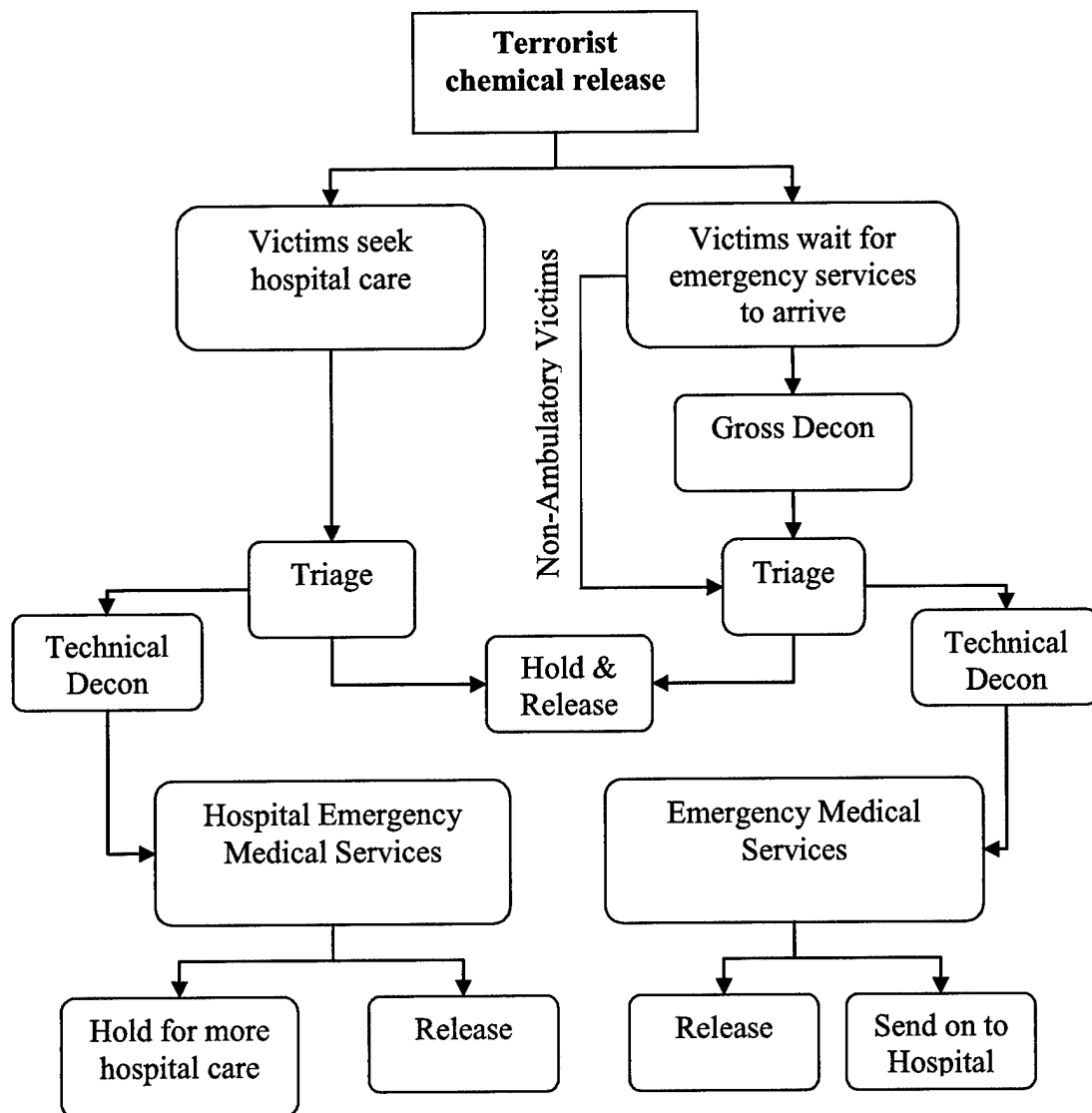


Figure 4.13 Flow Chart of Chemical Terrorism Planning Model

The chemical terrorism planning model portrays the flow of victims through the various emergency procedures at the scene or at area hospitals. The model begins at the incident site with a chosen number of victims exposed to the chemical agent. The victims are then broken into the following categories: ambulatory and non-ambulatory (including the dead), those who remain on-scene and convergent casualties, and the “worried-well” at both the incident site and at hospitals.

As stated previously, ambulatory victims are those that can walk, while non-ambulatory are those that cannot. Convergent casualties are those victims that self-evacuate from the scene to area

hospitals, rather than wait on-scene for medical attention. The “worried-well” are individuals who experience symptoms primarily due to the stress and shock of the terrorist incident, and will demand attention from the emergency response community. The model assumes that five percent of the victims die on the scene before medical attention arrives (See Table 4.4). While this is an explicit assumption of the author, several counter-terrorism personnel from the Los Angeles TEW found these assumptions plausible. The cause of death may be acute poisoning by the chemical, from being trampled in the exodus from the incident scene by other victims, or other causes (e.g., heart attack caused by the panic, initial blast if explosives were used to spread the chemical, etc.). The counter-terrorism coordinators from LAFD, LACoFD and LA DHS believe that approximately 70 percent of the victims will be convergent casualties—self-evaluating to area hospitals—which was the approximate percentage in Tokyo after the 1995 Aum incident. Thus, approximately 70 percent of the living casualties in the table below are convergent casualties (70 percent of the living 95 percent is 66.5 percent of the total). The coordinators estimated that an additional seven percent would be living, but non-ambulatory, and most of these would remain on scene, with some being taken by others to the area hospitals. The 1995 Aum incident provided no parallel assumption; however, the counter-terrorism coordinators felt that the number was reasonable. All of these assumptions can be explored if subsequent users of the model want to test outcome parameters.

Victim Type	Destination	Percentage
Non-ambulatory	On-scene	0.050
Non-ambulatory	Hospital	0.020
Ambulatory	On-scene	0.235
Ambulatory	Hospital	0.645
Dead	On-scene	0.050
Total		1.000

Table 4.4 Percentages for Physical Victim Categories

¹⁴⁵ This is an assumption of the author and supported by several counterterrorism personnel from the Los Angeles TEW.

¹⁴⁶ There was no precedent to this assumption provided by the Aum incident; however the group felt that the number seemed reasonable.

Table 4.4 does not include one very important group for consideration, that is the “worried well.” The “worried well” may indeed have had minor exposure to the chemical agent, but their exposure was so minimal that medical services or even decontamination are largely unnecessary. However, the “worried well” will place a strain on the emergency medical and response system at the scene of the incident and at area hospitals. In the Tokyo sarin experience, of the approximately 5,000 victims, roughly 4,000 or 80 percent were thought to be “worried well.” Based on this, 80 percent of the victims in the simulation are identified as “worried well.” Since these patients did not have severe exposure to the chemical, they are also considered ambulatory. Therefore, the model treats all of the “worried well” as such. Table 4.5 shows the notional percentages associated with each of the above categories when 80 percent of the total victims are considered “worried well.”

Victim Type	Destination	Percentage
Non-ambulatory	On-scene	0.010
Non-ambulatory	Hospital	0.004
Ambulatory	On-scene	0.047
Ambulatory	Hospital	0.129
Worried-Well	On-scene	0.240
Worried-Well	Hospital	0.560
Dead	On-scene	0.010
Total		1.000

Table 4.5 Percentages for Total Victim Categories Used in Simulation

On-scene Decontamination Process in Model

In the Chemical Terrorism Planning Model thirty percent of the living victims (29.7 percent of the total) remain at the scene of the attack. The contaminated and “worried-well” wait a few minutes for the first arriving fire company, which would instruct the ambulatory victims to move towards their engine to be showered by their large hoses—receiving gross decontamination. The model uses the LA area data suggesting that the arriving companies take five minutes to be at the scene, and then use an additional five minutes for the team to assess the scene and to start the gross decontamination process—turning on their hoses. The capacity of gross decontamination based on exercise data is

approximately 13 individuals going through the process every minute, or approximately 800 individuals an hour.¹⁴⁷

By definition, non-ambulatory victims will not be able to take themselves to the gross decontamination site, and will instead wait for arriving paramedics or others to assist them in triage.¹⁴⁸ The triage process is run by paramedics who will make a determination of whether the victim should proceed directly on to technical decontamination (all victims will be triaged), or whether they should first receive emergency medical services before proceeding on to technical decontamination. In Los Angeles the paramedics are the most qualified individuals to run the triage procedure, and this process should take from 30 seconds to 1 minute per victim.¹⁴⁹ The model uses a triangular distribution of $t(0.5, .75, 1)$ minutes for the paramedics to perform triage.¹⁵⁰ If the chemical is identified and determined that technical decontamination is not required, then the model can end after the gross decontamination process. Otherwise it is assumed that the victims will require technical decontamination.

The model simulates three types of victims that the paramedics will confront in triage. The first type of victim appears contaminated but is in stable condition. The paramedics would send this victim to the queue for technical decontamination. The second type of victim appears symptomatic of chemical exposure but is not in stable enough condition to proceed on to decontamination at this time. Instead the paramedic will send the victim on to other paramedics and emergency medical technicians for emergency medical stabilization services (e.g., oxygen, antidote, ventilation, etc.) and then on to queue for technical decontamination. According to the leaders of the paramedic training and county medical disaster physicians, this emergency procedure takes approximately two to five minutes,

¹⁴⁷ The individuals going through the gross decontamination would stay in the flow of water for approximately 10-15 seconds. The number comes from exercises with 200 processed in fifteen minutes. With smaller numbers, the individuals could stay longer under the water, or may need to move faster with larger numbers of victims. The control of the people waiting for gross decontamination is a potential friction in the system.

¹⁴⁸ Triage in this situation would be to prioritize the technical decontamination and medical services. Paramedics would determine who had been exposed potentially to the liquid form of the chemical, who appeared symptomatic, and who may be considered "worried well."

¹⁴⁹ The time is based on discussions with training staff of the LACoFD paramedics.

¹⁵⁰ The triangular distribution uses the parameters (a) minimum, (b) median, and (c) maximum— $t(a,b,c)$. The triangular distribution is useful when little is known about the distribution. In the chemical terrorism model the minimum, median, and maximums used are estimates by the local experts based on exercises and offer a simple sensitivity analysis of the procedure.

because the focus of the paramedics will be on quick stabilization. Therefore, the model also uses a triangular distribution of $t(2, 3, 5)$ minutes for this procedure. The stabilized victim is then sent on to the queue for technical decontamination. The third type of victim does not appear to be contaminated and appears stable (i.e., "worried-well"). The paramedics would hold this patient in a separate area near triage for observation until contaminated victims are first technically decontaminated.

The model assumes that the paramedics will not be able to correctly differentiate all of the "worried well" from the truly symptomatic victims, and that they will err in favor of earlier decontamination rather than hold the questionable victims in a waiting area. The model initially has the paramedics having a false positive rate of 25% of the "worried-well." This percentage is not based on actual data, but represents an assumption of the author based on discussion with leaders in the paramedic community. This percentage is varied in subsequent runs to simulate better or worse training for the paramedics.

The ambulatory victims would then assemble at another collection point to wait for the more thorough technical decontamination. This waiting point is entitled "Queue for Technical Decontamination" in the model. The victims wait in this queue until emergency responders arrive and set up their technical decontamination equipment. For modeling in the urban areas of LACoFD's jurisdiction, the arrival time of strike teams (five fire companies) is assumed to be the first arriving five minutes after the first fire company arrives, the second strike team ten minutes after the first, the third an hour after the second, the fourth 90 minutes after the third, and the fifth 180 minutes after the fourth. These times, as stated previously, are assumptions made by battalion chief-level members of the fire department based on years of experience. The first two strike teams are pulled from the nearby area, but the subsequent teams take longer to arrive since they are brought from throughout the county to ensure that sufficient capability is available for other emergencies.¹⁵¹

¹⁵¹ These times do not include using mutual aid, but rather brining resources to the location from a single department.

The first of the two Mass Decontamination Units arrive 45 minutes after being requested by the initial fire company, and the second MDU arrives ten minutes later. These two units are stationed together, but require LAFD firefighters to man and transport them. These arrival times were given by senior LAFD officials, but can be varied in the model. Likewise, if mutual aid is requested, two additional strike teams from either LAFD or LACoFD can be on the scene within 30 to 40 minutes to assist the other fire department. Thus the model assumes the arrival of the first mutual aid requested strike team at 30 minutes and the second at 40 minutes into the incident. The arrival times for all these units can be seen in Table 4.6.

Unit	Arrival Time
1st Engine	T+5
1st Strike Team	T+10
2nd Strike Team	T+20
1st Mutual Aid Strike Team	T+30
2nd Mutual Aid Strike Team	T+40
1st MDU	T+50
2nd MDU	T+60
3rd Strike Team	T+80
4th Strike Team	T+170
5th Strike Team	T+350

Table 4.6 Arrival Times in Minutes of Responding Units (T=Time of the Incident Reported to Dispatch)

The model has the county's mobile cache of PPE and decontamination equipment arriving 50 minutes after the incident started.¹⁵² Again this arrival time is based on assumptions of senior fire officials who work with the cache, and is also based on past exercises and the judgment of the officials. Depending on the exact location of the event, the cache might arrive sooner or later. However, all the officials asked to estimate arrival times responded with an average time they felt comfortable in achieving—not best or worst case scenarios. The use of average response times in this dissertation is used to illustrate this methodology, but is recommended not to be used in actual planning of a response. Averages do not take into consideration the variations in response times, including extremes, and can be deceptive when used. In this dissertation, with a lack of data, averages are used

¹⁵² The range of the response time for the equipment arrival could be 15 minutes to 120 minutes depending on the location and timing of the incident in the County.

to paint the picture of what may happen, but it does not take all possible variables into consideration. The averages supplied by the response officials provides a means to work through basic problems in the response mechanisms, but it would be beneficial to provide more modeling, outside the scope of this dissertation, to provide detailed response plans.

The strike teams, if they use the MCMD tent system, will need 20 minutes to set up after the single mobile cache arrives. The MDU takes 15 minutes to set up after arrival at the scene. The MCMD system has a capacity to decontaminate five people every five minutes (60 per hour). This breaks down to two males, two females, and one non-ambulatory victim decontaminated every five minutes. The MDU processes 13 individuals each five minutes—six male and six female on either side of the unit every five minutes plus one non-ambulatory victim during the same time period.¹⁵³

At the end of the technical decontamination process the model sends all of the technically decontaminated victims back to emergency medical services so the paramedics can check whether the victims should be sent on to hospital for further treatment or released. The time period for this process is the same triangular distribution as for triage— $t(2, 3, 5)$ minutes.¹⁵⁴

This portion of the model ends when all of the contaminated victims have been decontaminated and gone through emergency medical services. Therefore, the model ends before the triaged “worried-well” are decontaminated, since the decontamination of the “worried-well” is less urgent or not life-threatening.¹⁵⁵ This portion of the model also does not simulate on-scene victims going to the hospital after receiving on-scene medical services.

¹⁵³ For both the MCMD strike teams and the MDU process, the model simulates each victim spending five minutes in the decontamination process. This is the ideal time for decontamination. However, the model uses a normal distribution of $t(5, .2)$ to simulate variance in the amount of time in the decontamination process.

¹⁵⁴ The triage is based on the chemical identified. If the chemical has a longer period of time before victims become symptomatic, all victims would be sent onto hospitals for observation and possible treatment.

¹⁵⁵ The model assumes that those deemed “worried well” in the triage process are indeed not contaminated. In reality there would be false negatives. The leaders of the paramedics in LAFD and LACoFD stated that they would rather err on the side of false positives than false negatives. For this reason, and for simplicity in the model, the false negatives are not added into the model. This is later discussed in Chapter Five.

Hospital Decontamination Process in the Model

As stated above, approximately seventy percent of the victims are expected to evacuate themselves to area hospitals. The model uses a triangular distribution of $t(5,15,25)$ to approximate the travel time to area hospitals.¹⁵⁶ This distribution was determined through discussions with medical disaster specialists in Los Angeles, and represents the travel to both nearby hospitals as well as more distant hospitals that are more familiar to the victims. In Tokyo victims went to a dozen different hospitals, and the chemical terrorism planning model assumes that the victims will go to up to ten area hospitals. However, this variable can be adjusted from one to 80 hospitals (the number of emergency care hospitals in the county). An additional assumption in the model is that the victims distribute themselves evenly among the chosen number of hospitals. This clearly would not be the case in real life. However, this assumption was made to simplify the simulation. The next chapter will examine the response at hospitals when victims present themselves unevenly. If more victims went to the closest hospital, this would result in more time required to decontaminate these victims at that hospital. The simulation's purpose is not to determine the exact time of decontamination, but rather to examine policies that might reduce lives lost and injuries sustained. Thus the equal distribution assumption can be used.

If there is no prior warning, there is a twenty minute set-up time for decontamination services after the victims arrive at the hospital. This represents the set-up time of the shower(s) and time for the selected hospital personnel to don their PPE. Hospitals may in fact be warned to expect contaminated patients after the firefighters and paramedics arrive at the incident scene, but some may only become aware of the situation as convergent casualties arrive.¹⁵⁷ For this dissertation it is assumed that the hospitals are notified at approximately the same time as the first arriving convergent casualties. The capacity of the hospital decontamination equipment is one person per shower per five minutes.¹⁵⁸

¹⁵⁶ The time for travel is a function of the hospital's location, and the average time would be longer the farther away the hospital used.

¹⁵⁷ This was the case of many of the hospitals in Tokyo during the 1995 Aum incident.

¹⁵⁸ The model again uses a normal distribution for this time of $t(5,2)$ to represent the decontamination time rather than exactly five minutes.

While the hospital can provide outdoor triage, the full medical services available for the victims lie inside the emergency room. Therefore before the victims can gain medical services they must pass through decontamination. The triage role is to prioritize who goes through decontamination first. Again, the model provides at first for 25 percent false positives among the "worried-well" placed into the queue for decontamination with the contaminated victims.¹⁵⁹ This part of the model ends when all of the individuals triaged for technical decontamination are decontaminated.

The chemical terrorism planning model ends at the hospital when all the victims have been through the technical decontamination process. The model records the time from the beginning of the incident until each individual victim has been through the technical decontamination process. These times are then exported into Microsoft Excel for additional analysis and for graphic presentation.

The Model

Figure 4.14 below shows a visual representation of the model, including the hot zone (where the chemical agent was released), the warm zone (where decontamination and emergency medical services take place), and the cold zone (where victims are released or then sent on to a hospital). The model also shows this process without the zones at a hospital, where decontamination would take place before contaminated victims are admitted.

¹⁵⁹ The hospital portion of the model also assumes the chemical is like parathion, requiring technical decontamination. If chlorine or phosgene were used, identified on-scene, and hospitals notified, then the victims could receive gross decontamination (if available), observed, and the triage would be based on the presence of the victims at the scene and their likelihood of exposure.

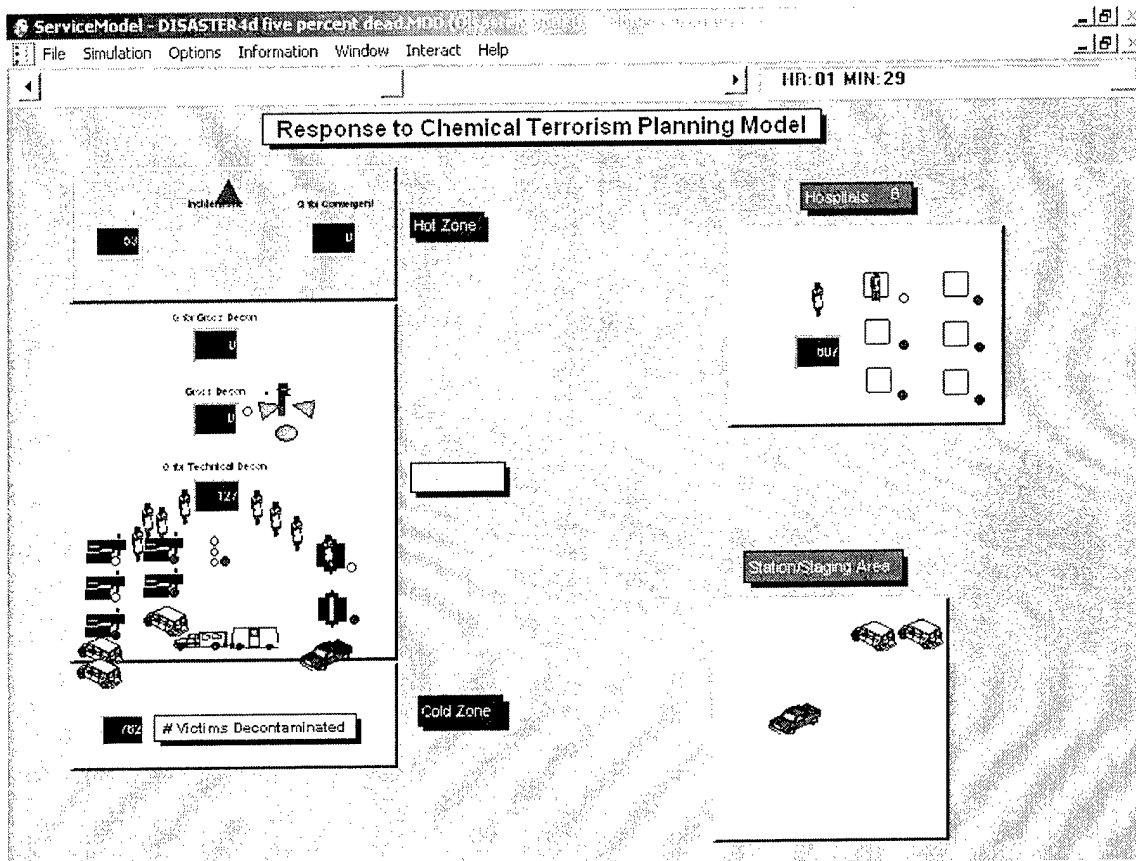


Figure 4.14 Visual Representation of the Chemical Terrorism Planning Model

Variables in Model

Within the planning model Table 4.7 shows the variables and their ranges that can easily be manipulated to simulate changes in the response. The minimum and maximum ranges represent the feasible range of response entities.¹⁶⁰

¹⁶⁰ The number of strike teams and MDUs represent the current feasible number for response. The maximum number of paramedics represents 50 percent of the on duty paramedics in LACoFD or LAFD, and is the maximum number available to respond to a scene. The range of showers represents a feasible number that could be installed at a hospital. The number of hospitals is based on discussion with responders on the number of hospitals that victims may travel or be taken to after the incident.

Variables	Range	
	Minimum	Maximum
Number of Victims	1	100000
Number of Strike Teams	0	5
Number of Paramedics	0	50
Number of MDUs	0	2
Number of Showers/Hospital	1	6
Number of Hospitals	1	10

Table 4.7 Variables in the Chemical Terrorism Planning Model

There are other variables that can be changed to reflect doctrinal, organizational, training and/or equipment changes. These changes would require making changes in the model itself, rather than simply the input variables. Examples of these other attributes would be arrival times and capacity of the responding units.

Baseline Results of Chemical Terrorism Planning Model

Figure 4.15 below shows the results of on-scene technical decontamination from the chemical terrorism planning model based on the baseline assumptions of the LAFD and LACoFD. It is further assumed that everyone deemed contaminated during triage goes through the technical decontamination process.

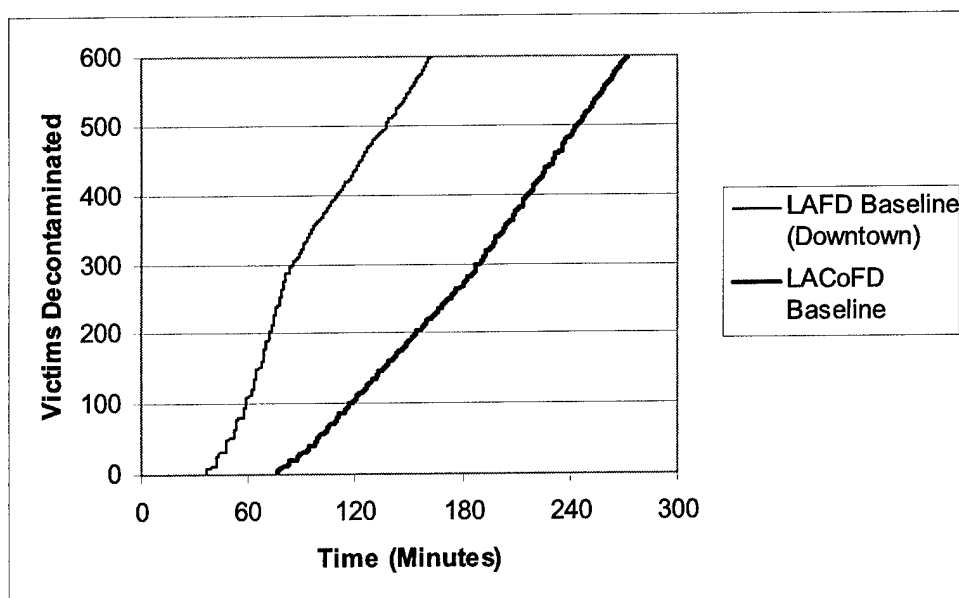


Figure 4.15 Baseline Technical Decontamination Rates of an Incident responded to by LAFD in the LA Downtown Area or LACoFD Elsewhere in the County without Requesting Mutual Aid.

In the following chapter the baseline will be run for five various locations throughout Los Angeles County to show the difference in response based on geography. However, for this first baseline analysis, the results show the time necessary for LAFD to technically decontaminate 600 individuals. This is based on 1,000 contaminated victims, of which 300 remain on the scene of the attack. An additional 1,200 “worried well” individuals also remain on the scene of the incident, and in this baseline model the triage procedures had twenty-five percent false positives (i.e., 300 individuals also put through technical decontamination). The following chapter will also show various false positive rates as well and numbers of individuals who remain on-scene.

In the Figure 4.15 above, LAFD has a faster response and decontamination rate than LACoFD. This is due to the greater concentration of firefighters in the Los Angeles downtown area, which results in having greater capability to process the contaminated victims if the incident took place in the Los Angeles downtown area. LAFD firefighters also can start decontamination sooner since they do not need to wait for their PPE to arrive (their chemical PPE is located on their fire apparatus). However, the steep initial slope of the LAFD response in Figure 4.15 turns shallower half-way through

as a lag occurs due to gross decontamination throughput.¹⁶¹ LACoFD's jurisdiction covers a large geographic area, and as a result units may not be able to respond as fast with their specialized equipment, nor bring as many firefighters to the scene as quickly as LAFD in the downtown area.

The hospital baseline is shown below in Figure 4.16. This is based on the assumption that the hospital is operating under the JCAHO standard of possessing the capability to decontaminate one person—typically a single shower. The baseline also assumes that twenty percent of the total convergent casualties (both contaminated and worried well) present themselves at this single hospital—Chapter Five will examine other distributions of victims—and that the initial triage of victims mistakenly places twenty-five percent of the worried well into the contaminated casualties queue for technical decontamination. The total number of technically decontaminated victims is 280 (140 contaminated victims and 140 worried well) out of a total of 700 individuals arriving at the hospital.

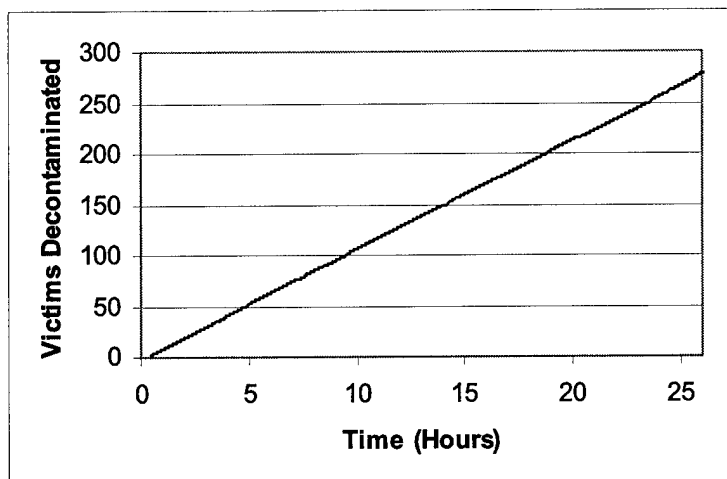


Figure 4.16 Baseline Capability for a Single Hospital to Technically Decontaminate 280 Victims

The single hospital baseline in Figure 4.16 above is purely theoretical, in that no victim will wait 26 hours to be technically decontaminated.¹⁶² However, until the hospitals in Los Angeles build additional capacity to technically decontaminate victims, they will only have the

¹⁶¹ More detail on this phenomenon is provided in Chapter Five.

¹⁶² Victims under this scenario would almost definitely take themselves to alternative locations for medical help if faced with a prolonged wait for medical services.

capacity to technically decontaminate one victim at a time. Clearly the hospital, under the stress of an actual event, would find alternative methods to decontaminated the victims, and in later chapters we will explore some of these alternative methods to find possible cost-effective solutions.

Baseline verses chemical scenarios

The Chemical Terrorism Planning Model provides the time at which each individual victim finishes gross decontamination, technical decontamination, or emergency medical services. Using these individual times, the probability of survival can be estimated by inserting the time the individual victims received decontamination into the function for the probability of casualties avoided curve for each chemical. Thus, as time for response (e.g., decontamination or emergency medical services) is altered based on policy changes or potential friction (e.g., traffic), the number of casualties avoided is likewise altered.

As stated earlier in the chapter, there is little data on which to base such casualty avoidance curves, so this dissertation uses a parametric approach. Two separate curves/equations based on estimates of the characteristics for each chemical are used: a low and high curve/equation representing the likelihood of survival or injury avoided (See Figure 4.2 for Parathion and Figure 4.3 for Chlorine, Phosgene, and Hydrogen Cyanide).

This exercise also relies on the assumption that all of the symptomatic/contaminated victims had the same exposure to the chemical used in the terrorist incident. In reality, these victims would have varying exposures based on elements such as the length of exposure, concentration of the vapor, weather, quantity of chemical sprayed/splashed on the victim, and proximity to the incident site. The assumption that all have the same exposure is to create a simplified baseline model, which can be expanded in future analysis. However, the reader should recognize that the results may be greater than expected, since the exposure in reality would not be uniform.

	Parathion		CL & CG		AC	
	High	Low	High	Low	High	Low
LAFD	189	114	150	86	0	0
LACoFD	174	95	149	55	0	0

Table 4.8 Casualties Avoided by Baseline Efforts for LAFD in Downtown and LACoFD in County for Parathion, Chlorine (CL), Phosgene (CG), and Hydrogen Cyanide (AC); 300 Total On-Scene Contaminated Casualties.

Table 4.8 shows the potential casualties avoided because of the baseline technical decontamination procedures and subsequent emergency medical services of both LAFD and LACoFD. These numbers represent the additional casualties that would have been incurred had LAFD or LACoFD not provided decontamination or subsequent emergency medical services. As can be seen, with hydrogen cyanide (AC) it does not matter whether technical decontamination took place or subsequent medical services provided—no additional lives were saved or injuries avoided.¹⁶³ For parathion, chlorine (CL) or phosgene (CG) there exists a range of casualties avoided due to the response capabilities.¹⁶⁴

	Parathion		CL & CG		AC	
	High	Low	High	Low	High	Low
Hospital	130	45	310	25	0	0

Table 4.9 Casualties Avoided by Hospital Baseline Efforts for Parathion, Chlorine (CL), Phosgene (CG), and Hydrogen Cyanide (AC); 700 Total Contaminated Casualties.

Table 4.9 above lists the casualties avoided based on the hospital baseline capabilities, or in other words, the number of additional casualties that would have been incurred had the victims not received decontamination or medical services. As with the on-scene response, there is little that the hospital can do to prevent additional casualties from a hydrogen cyanide exposure.

¹⁶³ Emergency medical services, such as administration of antidote and oxygen can help speed the recovery of those who have received a less-than-lethal dose of hydrogen cyanide, but the lack of medical attention will not lead to further death or injury.

¹⁶⁴ The response to parathion is only for technical decontamination and emergency medical services, while the range of casualties avoided for chlorine and phosgene only assumes gross decontamination and medical services.

Chapter Five will explore options that would increase the numbers of casualties avoided at both the incident site and at hospitals. In the next chapter the casualties avoided based on the proposed options will be compared with the baseline numbers above.

Conclusion

This chapter has focused on the capabilities in Los Angeles to both prevent a chemical terrorist attack as well as to respond to one should it occur. The capabilities discussed in the chapter represent those currently available in the Los Angeles metropolitan area. Using the planning magnitude of a 1,000 victims from Chapter Three, a model was created to simulate the response to a chemical terrorist attack. A scenario was also described to illustrate the current process and times associated with the current capabilities and response posture. If the desire were to save more lives and prevent additional injuries, the current baseline capabilities would need to be improved. The next chapter will discuss cost-effective options to save lives and/or avoid injuries.

Chapter Five: Cost-Effective Programs

This chapter examines cost-effective programs to respond to a chemical terrorist event. Specifically, the chapter will examine the existing baseline capabilities and costs, and then outline various options to increase capabilities that will reduce the number of casualties in a chemical terrorist event in a cost effective manner. As described in the planning framework in Chapter Two, the third domain question to be answered is, What alternative strategies can provide the desired performance level at what cost? Multiple cost-effective options or mixes of responses may be available, and there may not be a single best method or mix. Rather, there may be a number of combinations of response strategies that lead to the desired capability level. These combinations, or operational concepts, are a mix of improvements in equipment, training, organization and/or doctrine. The focus of this dissertation will be to identify low-cost solutions that increase overall capabilities that would be robust in the face of uncertainty.

In this chapter, cost-effective options for response to chemical attacks will be explored through modeling and simulations and subsequent analysis. This analysis will generate cost corresponding to the capability level identified in Chapter Four that can then be used in the final domain of the planning framework. The model seeks options that provide the "biggest bang for the buck" in providing decontamination and emergency medical services to victims. We shall examine costs associated with a reduction in casualties caused by the four chemicals (chlorine, hydrogen cyanide, phosgene, and parathion) discussed in Chapter Three.

Improvements Needed: What's Wrong with the Baseline?

As was discussed in Chapter Four, the current baseline capability of LAFD, LACoFD, and area hospitals to respond to a chemical terrorist attack involving 1,000 symptomatic victims and 4,000 worried well does provide some benefit in treating casualties, but there are many aspects of the

response effort where improvements could be made to help prevent additional injuries or loss of life. This portion of the chapter will focus on the baseline on-scene response performance, while the hospital baseline will be discussed later.

As was seen in Chapter Four, the responsiveness to the incident was not timely—victims waited over an hour to receive technical decontamination. The long period of time before technical decontamination was started was a result of the time of arrival for the cache of equipment (i.e., personal protective equipment of the emergency responders, tent systems, decontamination material, and emergency suits for victims' modesty), and set-up time for the equipment (e.g., tent systems). The result of waiting to start might lead to more casualties sustained among the victims, whether by a continuation of poisoning (e.g., parathion) or a delay in receiving medical attention (e.g., chlorine and phosgene). Victims exposed to hydrogen cyanide would benefit little from decontamination or medical services unless an antidote was administered within the first five minutes—beyond the capabilities of the emergency response personnel assumed herein.

An additional problem with the baseline lies in the current practice of providing gross decontamination. The first arriving fire company provides gross decontamination, while the second arriving company takes over incident command and starts the process of technical decontamination. In past exercises, the original arriving company possessed adequate capability for providing gross decontamination throughput, but these exercises had fewer than 100 victims—thus creating the impression that one company providing gross decontamination was adequate. Using one engine to provide gross decontamination in baseline model runs, the throughput was insufficient to keep up with the capacity of the technical decontamination, creating a bottleneck and reducing overall decontamination time (See Figure 5. 1 below as an example.).¹⁶⁵

¹⁶⁵ Gross decontamination is not required before technical decontamination, however it may be all that is required to decontaminate a victim depending to what chemical the victims were exposed. Until the chemical is identified, gross decontamination is a procedure that can provide some level of decontamination for the victims, however it may not completely free the victim of their chemical contaminants.

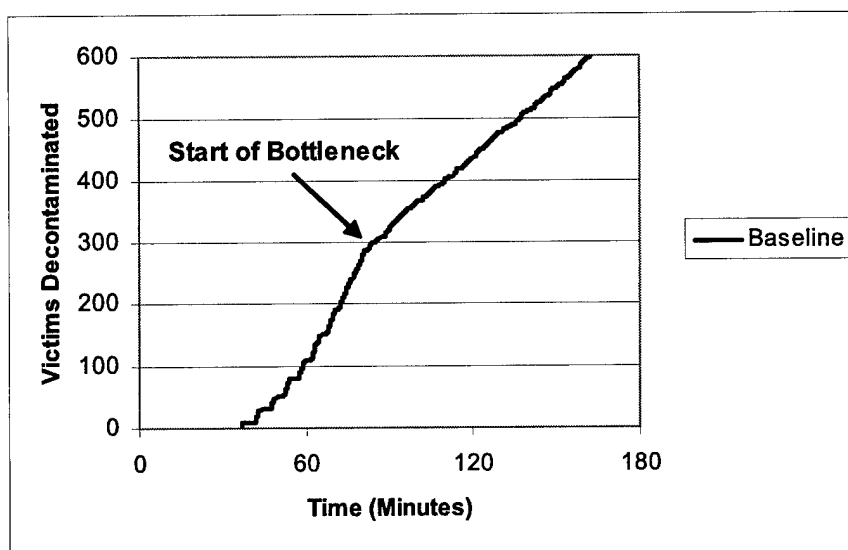


Figure 5.1 Bottleneck in the Baseline Technical Decontamination Process in Downtown Los Angeles Due to Single Engine Company Providing Gross Decontamination

This is an artificial situation brought forward by the model. In a real incident, most likely, the incident commander would not allow such a bottleneck to form, however any delay in recognizing a bottleneck might slow down the overall response. Additionally, in a real incident patients would most likely not wait in an orderly line for gross decontamination, but rather force their way towards the single gross decontamination station or leave for other emergency services. An increase in gross decontamination stations would help avoid the crowding, and by at least doubling the gross decontamination the bottleneck is also avoided.¹⁶⁶ The casualties avoided¹⁶⁷ by this simple fix for the chemical parathion can be seen in Table 5.1 below. The "High" and "Low" figures in Table 5.1 and subsequent tables throughout this chapter represent the high and low probability of casualties avoided curves described previously in Figure 4.2. As described in the previous chapter, since the exact number of casualties avoided is unknown, this dissertation uses this parametric approach. The true number of casualties avoided would most likely fall within these two (i.e., high & low) figures.

¹⁶⁶ Similarly, in a real event if there was a bottleneck, the incident commander could send some of the patients directly to triage and technical decontamination without first going through gross decontamination.

¹⁶⁷ The phrase "casualties avoided" is used throughout this chapter to mean deaths and serious injuries that did not take place due to emergency care provided at the scene of the incident or at hospitals.

	Parathion	
	High	Low
LAFD Downtown Baseline, 1 Gross Decon	189	114
LAFD Downtown Baseline, 2 Gross Decon	192	118

Table 5.1 Casualties Avoided for a LAFD Response to Downtown Los Angeles Parathion Scenario with One or Two Engine Companies Providing Gross Decontamination

This simple gross decontamination fix can be performed for little to no additional cost, since as a doctrinal fix it only involves existing equipment. However, the increase in gross decontamination plays a larger role for the decontamination process for the chemicals chlorine and phosgene, since exposed victims do not need to go through technical decontamination unless contaminated by the liquid form of the chemicals. Thus, the arriving companies can focus on gross decontamination and emergency medical services, rather than on technical decontamination. Table 5.2 below shows the benefit in terms of lives saved and/or injuries avoided based on the number of gross decontamination stations in response to a chlorine or a phosgene incident.

	CL & CG		Time (Minutes)
	High	Low	
1 Gross Decontamination	127	65	156
2 Gross Decontamination	138	74	86
3 Gross Decontamination	141	76	63

Table 5.2 Casualties Avoided for a Response to a Chlorine (CL) or Phosgene (CG) Scenario with One to Three Gross Decontamination Stations for the On-Scene Victims: 1,500 Individuals Sent Through Gross Decontamination of which 300 Are Contaminated Victims.

The sooner victims exposed to chlorine or phosgene are processed through gross decontamination, the sooner they can receive emergency medical attention and/or be transported to a hospital, since they most likely will not need to go through the full technical decontamination. Individuals exposed to hydrogen cyanide will also most likely not need to go through technical decontamination, however there will likely be no additional casualties avoided since those who will die or be seriously injured will have suffered death and injury before help arrives, and as was described in Chapter 4 there is little that can be done five minutes after the exposure. Since individuals exposed to parathion would require technical decontamination, most of the subsequent discussion and scenarios requiring technical decontamination will focus on a parathion exposure.

Equipment, Doctrine, Organization and Training

As was briefly described in the previous chapter, there are several possibilities for making improvements to the current methods of responding to a chemical terrorist event affecting either response or capacity. Response is the ability to provide the most appropriate decontamination and/or medical services in an effectively timely manner, while capacity relates to the rate at which victims can be processed. Improvements in response and capacity can be made through positive changes in 1) equipment,¹⁶⁸ 2) training, 3) organization and/or 4) doctrine. A change in any or all of these areas might reduce response time and/or increase capacity, improving performance as a whole.

Changes in equipment can come through acquiring additional equipment and/or through supporting research and development (R&D),¹⁶⁹ which will improve the equipment in the future. Equipment improvements can impact response by facilitating arrival on the scene faster and with less set-up time required, and can affect capacity through more effective decontamination technologies. Training can help maintain essential baseline capabilities, and improved training (i.e., more effective or frequent training) might decrease response time by shortening set-up times or improving capacity, allowing responders to more effectively decontaminate, perform triage, and provide basic medical needs for victims. Organizational changes can place resources more effectively, which may provide an improved response time. Doctrinal changes can include methods that streamline triage, decontamination, or other necessary processes.

Figure 5.2 shows notionally how changes in response and capacity specifically affect the decontamination process. The changes in response and capacity, represented in the figure, might have been improved through equipment, training, doctrine, or organizational changes. New high capacity equipment or improved training might improve the throughput of victims through the decontamination process, thus changing the slope of the line. Decentralizing equipment throughout the area, or purchasing more equipment may improve the response time to the scene, and thus shift

¹⁶⁸ Increases merely in equipment or manpower would eventually result in diminishing marginal utility.

the line to a new start time to the left. A combination of these changes could improve both throughput and response, which would shift and change the slope to the left as shown in Figure 5.2. Specific examples of these changes in equipment training, doctrine, or organizational changes will be explored in this chapter.

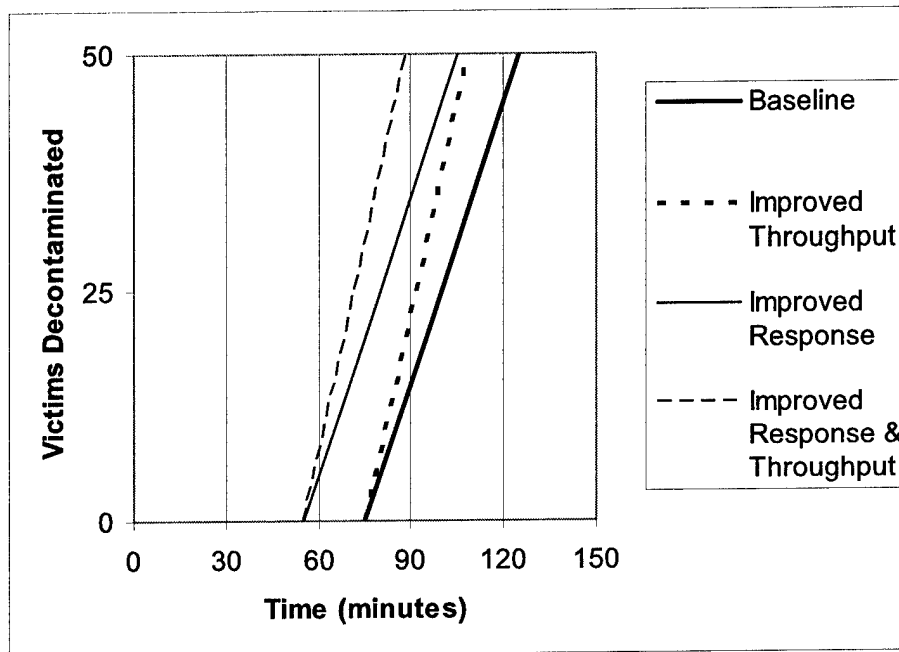


Figure 5.2 One Strike Team Tent System to Technically Decontaminate 50 Individuals

What Is the Baseline Cost?

In examining the costs necessary to provide improvements, it is important to understand the various components of these costs. First, there are one-time costs, those necessary to provide a new capability. One-time costs would include the cost of a new piece of equipment, or the costs to hire and train the personnel of a new fire company. Second, there is the daily cost to maintain a unit. This daily cost is the same regardless of whether the unit is responding to an incident, training, or awaiting deployment. The third component consists of the sunk costs—those costs that are already paid for and

¹⁶⁹ Supporting R&D is not in the scope of local emergency responders, since even the sizable departments in Los Angeles are not large enough to support their own R&D base. R&D is left to the federal government or private enterprises. Therefore, this dissertation will not consider it for further examination.

non-recoverable (these represent former one-time purchases already made). For example, LACoFD has already spent approximately \$175,000 to purchase their tent system, and the Los Angeles World Airports have spent \$400,000 to acquire their mass decontamination units (MDU) at LAX. Both LAFD and LACoFD also have sunk costs associated with their current PPE—the county's cache and the city's on their engines. Thus, to use their present equipment there would be no cost (other than maintenance and eventual replacement). However, there would be a cost to purchase additional systems.

Equipment Costs

Currently the tent system has an acquisition cost¹⁷⁰ of \$35,000 for the tents and other related equipment used in the mass casualty process. The vehicle (e.g., Chevrolet Suburban) and trailer to transport the tents cost \$50,000 to purchase.¹⁷¹ LACoFD has five of these systems that are in a centralized location, which are transported by a single vehicle and trailer which (total cost of \$175,000).¹⁷² The two MDUs are located at the Los Angeles International Airport and have a cost of \$200,000 each, including the cost of the vehicle to transport the system. The MDUs, as mentioned in Chapter Four, require three fire companies to man the system.

Each of the firefighters providing decontamination or medical services within the hot and warm zone require personnel protective equipment. The basic PPE includes a "splash suit" (chemical-resistant jumpsuit), boots, gloves, and a mask/breathing apparatus. Both LAFD and LACoFD plan on their firefighters using their standard self-contained breathing apparatus (SCBA) and the boots that they

¹⁷⁰ The life-cycle cost of the tent system is unknown. At the time of this writing there have been no maintenance costs for the tents, no storage costs, nor a date for replacement of the tents.

¹⁷¹ If the vehicle was used exclusively for the cached equipment and had a seven year life span and \$2,000 per year for maintenance and other costs to operate, its life-cycle cost would be \$54,000.

¹⁷² LACoFD is in the process of breaking up the single cache into three, at a cost of approximately \$100,000 for the two additional vehicles and trailers.

already use in traditional fire emergencies. For the two departments, the cost of the new equipment needed is \$71 per ensemble per fire fighter, or \$284 per four-person fire engine.¹⁷³

Training Costs

Fire companies typically spend two hours per day training. This includes individual course work or training as a company. The LAFD and LACoFD each provide a set of standard training topics to their companies to follow in order to maintain consistent department-wide standards. In both of these departments, all of the companies received hands-on training on the MCMD system prior to the 2000 Democratic National Convention (DNC) held in Los Angeles. Since the preparations for the 2000 DNC, there has not been a system-wide retraining on this large a scale. Since 2000, most companies in LACoFD have received approximately four hours per year in refresher training—typically self-instruction at the company level for two hours, twice a year. Of the approximately \$37 million spent by LACoFD on training, around \$565,000 is spent department-wide on counter-terrorism training.¹⁷⁴

If the fire departments decided to bring all the fire companies in again, as was done for the 2000 DNC, for an eight hour session (including hands on training), the cost just for the fire companies, not including the trainers, would be a total of approximately \$1,130,000 for LACoFD and \$860,000 for LAFD.¹⁷⁵ These costs represent opportunity costs for the departments since companies would be brought in during duty hours and other on-duty companies would take over emergency response for those companies being trained. If Los Angeles leaders wanted to ensure that there was no decline in services during that time, off-duty companies could be brought in either for the training or to cover for those being trained; this would require that the off-duty companies be paid overtime. The total cost to

¹⁷³ The splash suit and gloves have a five-year shelf life, while the boots are expected to last 10 years. There is no anticipated maintenance or storage cost associated. The splash suits and gloves most likely would only be used once before being discarded, however the boots, if properly decontaminated could be used multiple times.

¹⁷⁴ Counter-terrorism training includes recognition of chemical and biological events, as well as conventional attacks, but the emphasis for the fire departments is on decontamination of victims. This does not include medical training. Source; discussions with the terrorism and training coordinators for LACoFD.

¹⁷⁵ Financial figures provided to the author by LAFD and LACoFD. The estimates are based on the approximate cost of \$240 per hour of personnel cost for a 4-person engine company. This assumes that each of the three shifts of personnel will be trained for all 148 engine companies of LAFD and 194 engine companies of LACoFD.

provide training in this manner would be approximately \$1.7 million for LACoFD and \$1.3 million for LAFD.

Organizational Costs

Currently in Los Angeles the task of mass casualty decontamination is left to the fire strike teams of the LACoFD with their MCMD tent system or LAFD with either MCMD (using LACoFD's tents through mutual aid) or with their own mass decontamination units. However, each department has its own model for how to distribute its equipment. LACoFD maintained until recently their tent system, decontamination supplies, and the chemical-specific PPE in one centrally located cache, ready to be brought to the scene after an incident took place. They now have broken the cache into three separate portions distributed in separate locations. For its part, LAFD has distributed its decontamination supplies and PPE with each engine, but is also dependent on some centrally located decontamination equipment (i.e., tents or MDU). The costs of organizational changes may often be reflected in necessary equipment purchases, since it may take additional or new equipment to allow for such change. As an example, an organizational option could be decentralizing the LACoFD equipment cache. Instead of placing the equipment with each fire company, it could be placed in multiple locations throughout the area. The change would entail the purchase of new equipment—additional trucks and trailers, as well as a small addition in PPE and decontamination equipment. Additional training costs would not be required since LACoFD is already trained in using the PPE and tent systems.

Doctrine Costs

Studying doctrine has little cost associated with it, other than the cost of the analysis necessary to examine various options and select the most effective methods. However, implementing doctrinal changes carries costs. In searching for low-cost doctrine options that may have a high impact on effectiveness, the single most promising change concerns when to proceed with decontamination procedures. This option will be discussed further below.

Cost of Increased Gross Decontamination On-Scene

The additional gross decontamination capability discussed earlier in this chapter is an example of a policy change that would have minimal cost. There is no additional equipment or training required to implement such a policy change. The only potential additional cost is of decontaminating the additional fire engines used in the gross decontamination process, since they would be located in the warm zone and could become contaminated.¹⁷⁶ However, it is highly likely that all engines used to respond to a chemical terrorist attack would be decontaminated to ensure that their future use did not jeopardize the safety of personnel, or spread contaminants elsewhere.

On-Scene Technical Decontamination

This section explores options to increase performance (decrease response and/or increase capacity) at the scene of the attack. The analysis will go through each of the four domain areas (i.e., equipment, organization, training and doctrine) where change is possible. While it is impossible to explore every possible option, those discussed below carry particularly low costs.

On-Scene Equipment

The two main large-scale decontamination systems used in Los Angeles are the tents systems and the mass decontamination units (MDU) located at LAX. The special purpose MDU provides more capacity/throughput with fewer required personnel, but is a much more expensive device to purchase. As can be seen in Figure 5.3 below, hypothetically three tent systems (15 tents in three batches of five) will provide nearly the same capacity as one MDU, but will require 15 fire companies, while the MDU only requires three companies.¹⁷⁷ The tent system, therefore, may reduce the number of personnel available at the scene to assist victims (as seen in the striped column below), and also leave fewer

¹⁷⁶ The crew would be needed to initially set up engine to perform the gross decontamination, but then the crew could be used elsewhere to provide technical decontamination or other services.

¹⁷⁷ This comparison is to show similar throughput capability of the MDU and tent systems, thus 15 tents are compared to one MDU. However, LACoFD has 25 tents (5 tent systems), and the 15 tents to equal the throughput capacity of one MDU represents 60 percent of LACoFD's total tent systems.

companies available to respond to other emergencies. The costs shown in white in Figure 5.3 are the sunk costs of systems that have been purchased in recent years.

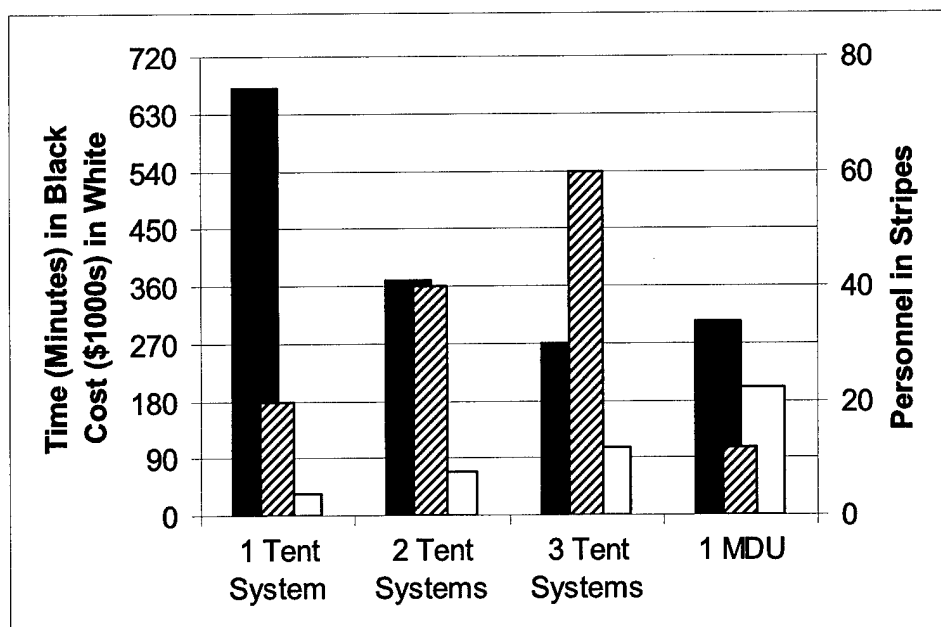


Figure 5.3 Comparison of Tent System vs. the Mass Decontamination Unit to Technical Decontaminate 600 Individuals; Including Acquisition Costs.

The Los Angeles public safety community may decide to purchase chemical response equipment different from what they presently own. The Mass Decontamination Units used in Los Angeles are manufactured by Modex. Other manufacturers are also creating decontamination trailers, however the number of showers (and hence capacity), does not differ greatly from the MDUs already in use in Los Angeles. It is conceivable that a self-propelled unit with more showers might be available in the future, but at this point there is nothing on the market greatly superior in capacity.¹⁷⁸

Increase in Engine Companies

A simple increase in the number of fire companies throughout Los Angeles would increase the number of personnel able to respond to a chemical terrorist attack. However, this would lead to significant costs to the region—a minimum of \$2.5 million per company for the first year and \$2 million

per year thereafter.¹⁷⁹ This includes the cost of the engine and the annual cost of three shifts of personnel to provide 24/7 coverage. In order to ensure an extra company was available near the location of an incident, multiple new companies would have to be added throughout the region, potentially driving the cost into the tens of millions of dollars. The increase in technical decontamination by one extra company brought to a scene would be 12 people per hour. While adding fire companies may have a dual use in terms of increased public safety, the added cost, solely for an increase for chemical terrorism, may not be justifiable.

Organizations: Centralization vs. Decentralization of Equipment for LACoFD

In the past, specialized equipment was centrally located in a single cache for LACoFD. LAFD split its equipment into three caches, as LACoFD just recently did. While centralizing the equipment makes it easier to maintain, there is the potential for the centralized cache to take longer to arrive to the scene of an incident than for one of the distributed caches. Currently, in LACoFD's jurisdiction, the first two strike teams can be at the scene in 15 minutes, but the third LACoFD strike team can take up to 70 minutes to arrive. This delay is caused by pulling assets from further away while ensuring that enough capability remains throughout the county to respond to other emergencies. Thus, for the first 70 minutes, only two LACoFD strike teams might be at the scene, even if the full cache arrived, only those two LACoFD strike teams would use the equipment.¹⁸⁰ Since the original LACoFD cache was broken into three parts¹⁸¹ and distributed throughout the area, then at least the portion needed for the first two strike teams can arrive more quickly. The other parts of the cache would arrive before or at the time the subsequent LACoFD strike teams arrived. The change in response is illustrated below in Figure

¹⁷⁸ This is based on market research conducted by the author on the Internet, attending two trade shows, and with discussions with manufacturers of currently available mass decontamination units.

¹⁷⁹ Data provided to the author by LAFD. What are not included in this amount are the training costs to certify the company, nor does the cost reflect the expense of new fire stations.

¹⁸⁰ Other firefighters brought in through mutual aid could also use the cached material, but following current expectations, only two strike teams (10 engines) from LACoFD would be on scene for the first 70 minutes.

¹⁸¹ Adding one additional tent and PPE for one more strike team to the original cache allows the material to be broken into three equal parts with enough material for two strike teams.

5.4. As a result of the decentralization of equipment, decontamination can start 20 minutes earlier¹⁸² (starting at 56 minutes after the incident instead of 76 minutes) resulting in only a modest improvement of 3 to 4 more casualties being avoided over the baseline capability—see Table 5.3.

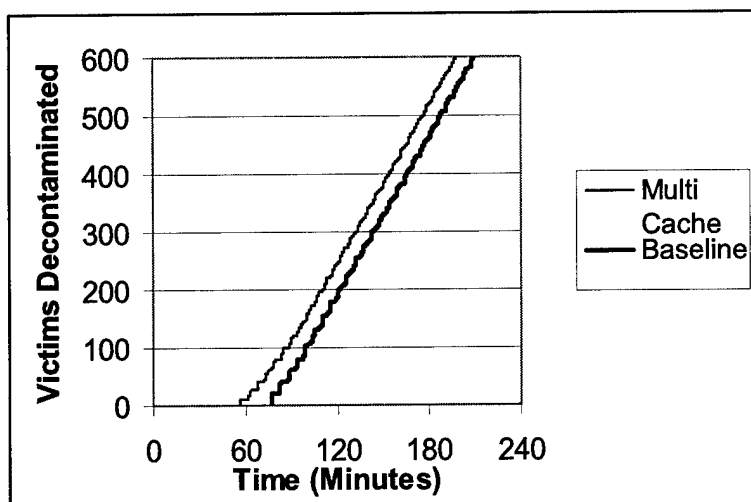


Figure 5.4. Single Original LACoFD Cache vs. Breaking Cache into Three Smaller Caches

	Parathion	
	High	Low
LACoFD Baseline	174	95
LACoFD Multi Cache	177	99

Table 5.3 Potential Casualties Avoided for Baseline and Multi Equipment Cache Options for LACoFD

The cache distribution choice is best made based on an understanding of the threat. If there is a higher probability for a modest number of casualties, then bringing a smaller capability to the scene sooner is the better option. If terrorist incidents could take place randomly throughout Los Angeles, then having multiple caches throughout the county is also logical. However, terrorism is not random; rather, targets are chosen purposely by the terrorists. Some areas within Los Angeles have a greater

¹⁸² The nominal twenty minute decrease was determined through discussions with terrorism coordinators in Los Angeles in view of locations for the caches and potential incident sites. Creating an average response for this response does not take into consideration the possibility for higher returns depending on the location of the cache and potential incident sites. This is explored later in the chapter in the discussion of Figures 5.9 and 5.10.

probability of suffering an attack than others. Terrorists may try to attack targets chosen by population, popular significance, and/or significance to the terrorists themselves.

The choice of where to locate equipment and units should be made keeping those high likely targets in mind. In Los Angeles, as elsewhere, not all such targets are centralized, so there should be a distribution that enables partial capability to reach an incident scene sooner than would be the case with only one centralized equipment location. Moreover, centralizing also creates vulnerability. If adversaries know where the specialized equipment and units are located, they may attempt to attack or otherwise hinder the deployment of those resources. A distributed approach helps alleviate that potential vulnerability.

LACoFD has two options for transitioning to a decentralized mode. First, as shown in the example, they could break the central cache into three smaller caches located throughout the area.¹⁸³ Second, the tents are distributed among three stations locations (as in option one), but the PPE and other decontamination equipment (hoses, sponges, soap, etc.) would be spread throughout the department on fire engines.

The cost for the first option (breaking up the cache into three), would be the purchase price of two additional vehicles and trailers (these would not have to be large vehicles since the amount of equipment carried would be smaller than in the original cache). The original cache had 5 tent systems, so in order to break the cache into three equal parts an additional tent and PPE for an additional strike team is required. The initial acquisition cost for this would be approximately \$136,820 (\$35,000 for an extra tent system, \$100,000 for two extra vehicles—most likely Chevy Suburbans¹⁸⁴—and trailers, and \$1,820 for PPE).

¹⁸³ The choice of three caches was determined by considering the least cost possible for additional tents. Presently LACoFD has five tent systems in its cache. By purchasing one additional tent system three smaller caches of two tent systems could be created. A minimum of two tent systems per cache is recommended since two strike teams can be in place of an incident in approximately 20 minutes, while the third strike team would take an additional hour to arrive.

¹⁸⁴ The higher cost for these vehicles from standard retail is due to additional specialized equipment that is required for fire departments (e.g., radio equipment, standard medical equipment, etc.).

The acquisition cost for the second option (distributing the PPE to all engines) for LACoFD would be approximately \$67,340 in addition to the cost of a third tent system and two extra vehicles from the first option.¹⁸⁵ LAFD has already chosen this option; however, the PPE is assigned to the engine and not the individual firefighter. This has resulted in each engine carrying four extra-large chemical resistance suits, in order to ensure that the PPE will fit any of the personnel who might be required to use it. In practice, this has created sizing problems. For each department to assign PPE to each operational individual, the additional acquisition cost would be approximately \$145,600 for LAFD and \$220,220 for LACoFD.^{186,187}

Of the two options, LACoFD could either spend \$136,820 to break up the cache into three parts, or and additional \$67,340 to \$220,220 to break up the cached tents and equip all its operational personnel in PPE. Both options will bring the tents faster to the scene, but the second would reduce set-up time, since the firefighters could don their PPE before the tents arrived. More details of the relative cost/benefit of these options will be explored later in the chapter.

On-Scene Doctrine

A suggested doctrinal change might be for the incident commander not to wait for the tents to be erected and to use other on-scene means to provide modesty protection, such as by conducting decontamination in parking structures or alleys, or using fire engines to shield male and female

¹⁸⁵ The cost of PPE for all 210 engine companies would be \$76,440, but LACoFD already has PPE for 25 engine companies in its central cache. If the existing PPE were distributed, then LACoFD would still need to purchase PPE for 185 companies for a cost of \$67,340.

¹⁸⁶ LAFD would need to purchase PPE for at least two thirds of its operational personnel—utilizing the PPE it has already purchased—and LACoFD would need to purchase PPE for all its personnel minus the PPE located in its cache.

¹⁸⁷ The mis-sizing of PPE may result in more casualties sustained due to a slower response as extremely large individuals are not able to fit in PPE or as smaller individuals are unable to perform as well in large PPE. However, the precise delay is unknown and not explored in this dissertation.

decontamination corridors.¹⁸⁸ Figure 5.5 below compares the options of waiting to set up the tents for modesty or not, if equipment arrived via either multiple caches or just one. No additional equipment needs to be set up upon arrival other than the tents. This doctrinal change has no economic cost, yet can provide a time savings of approximately 20 minutes and between four to ten casualties avoided (See Table 5.4).¹⁸⁹

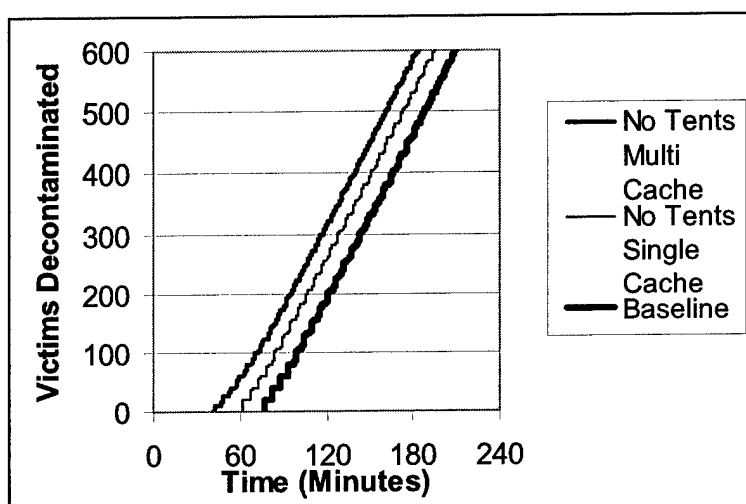


Figure 5.5 Comparison of Baseline, No Tents & Multi Equipment Cache, and No Tents & Single Equipment Cache Options for LACoFD

	Parathion	
	High	Low
LACoFD Baseline	174	95
LACoFD Multi Cache	177	99
LACoFD No Tents/Single Cache	178	99
LACoFD No Tents/Multi Cache	182	105

Table 5.4 Casualties Avoided for Baseline, No Tents & Multi Equipment Cache, and No Tents & Single Equipment Cache Options for LACoFD

¹⁸⁸ The tents provide "an area of refuge and relief for contaminant removal; modesty protection for disrobing; and an area for donning clean clothing....", Ronald Watson, "County of Los Angeles Fire Department Multi-Casualty Mass Decontamination Plan for the 2000 Democratic National Convention," 2000 Annual Report, The InterAgency Board for Equipment Standardization and InterOperability, April 2001. The tent system also provides a roller-type platform to move non-ambulatory victims through the decontamination process. If the tent system was not used, firefighters could still decontaminate non-ambulatory victims, but it might take slightly longer to do so. However, ambulatory victims could be decontaminated in the same amount of time, since the tents only provide shelter.

¹⁸⁹ This is again based on average planning factors. The average real effect could show that there is less impact than breaking up the caches for locations in the city, however, even if the caches arrived, the tents would need approximately 20 minutes to set up, and thus this option would still provide benefit in time reduction, and thus benefit in casualties reduced.

If the departments disperse the personal protective gear, firefighters do not need to wait for a central equipment cache to arrive before they can suit up in their PPE and have the basic decontamination equipment they need. With equipment in the hands of the fire companies, and with a change in doctrine to forego the modesty protection of the tents, the companies can start the process of technical decontamination almost immediately, reducing 55 minutes from the current LACoFD baseline time to start decontamination.¹⁹⁰ This 55 minute reduction would allow 150 victims to be decontaminated before the current process would have been ready to start, as seen in Figure 5.6 below.¹⁹¹ This new process would result in 12 to 17 lives saved and/or injuries avoided, as seen in Table 5.5 below.

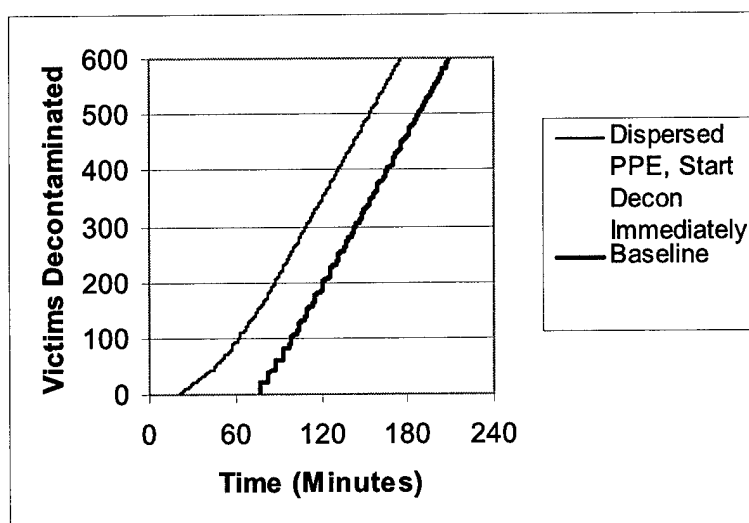


Figure 5.6 Technical Decontamination Starting Immediately with Dispersed PPE vs. Waiting for Equipment And Using Tents (Baseline)

¹⁹⁰ It may seem that the decrease in time would be 70 minutes (20 saved from not setting up the tents and 50 saved from the arrival of the cached equipment). However, the strike teams would still need to arrive at the scene and put on PPE—part of that arrival time was concurrent with the arrival of the equipment.

¹⁹¹ The fire departments would also forgo using the non-ambulatory roller system, which would make the decontamination process less convenient, but would not significantly change the time.

	Parathion	
	High	Low
LACoFD Baseline	174	95
LACoFD Multi Cache	177	99
LACoFD No Tents/Single Cache	178	99
LACoFD No Tents/Multi Cache	182	105
LACoFD Dispersed PPE/Start Immediately	186	112

Table 5.5 Casualties Avoided for Baseline, No Tents & Multi Equipment Cache, and No Tents & Single Equipment Cache, and Dispersed PPE & Starting Immediately Options for LACoFD.

LACoFD and Mutual Aid

When responding to a chemical incident, the LACoFD and LAFD will most likely assist each other.¹⁹² However, if simultaneous attacks take place in each department's area, they may not be able to assist each other through mutual aid. As we saw in the September 11th attacks and the embassy bombings in 1998, the method of operation for the terrorists was to attack multiple targets simultaneously (e.g., attacking both towers in New York as well as targets in Washington, DC). Thus, there is a precedent for simultaneous attacks, which may cause departments to be less willing to provide mutual aid after any single attack (i.e., the other departments might not be willing to commit personnel in case an additional attack takes place in their own jurisdiction). For this reason, both LACoFD and LAFD are examined in this chapter independently as well as together in a supporting mutual aid role. If LACoFD does receive mutual aid, the types of support will depend on decisions the two departments make in advance in terms of organization and doctrine.

Figure 5.7 and Table 5.6 below represent several types of mutual aid that LACoFD can receive from LAFD, as detailed in the Chemical Terrorism Planning Model. The first option, using additional strike teams from the city, and with all the strike teams starting technical decontamination immediately without waiting for tents, would begin 55 minutes earlier than under the baseline doctrine. This would allow 152 victims to be decontaminated before the baseline process would start, and would finish 34 minutes sooner than in the baseline scenario—as a result 112 to 186 casualties would be

¹⁹² If simultaneous attacks take place in each department's area, they may not be able to assist each other through mutual aid.

avoided instead of the baseline's 95 to 174. A second option would bring in the additional LAFD strike teams (all starting immediately without tents) and the two MDUs. This would again start 55 minutes earlier, but would be able to decontaminate 187 victims before the start of the LACoFD baseline process, and complete the decontamination 87 minutes sooner. This process, in a parathion scenario, would lead to 119 to 192 casualties avoided instead of the 95 to 174 in the baseline.

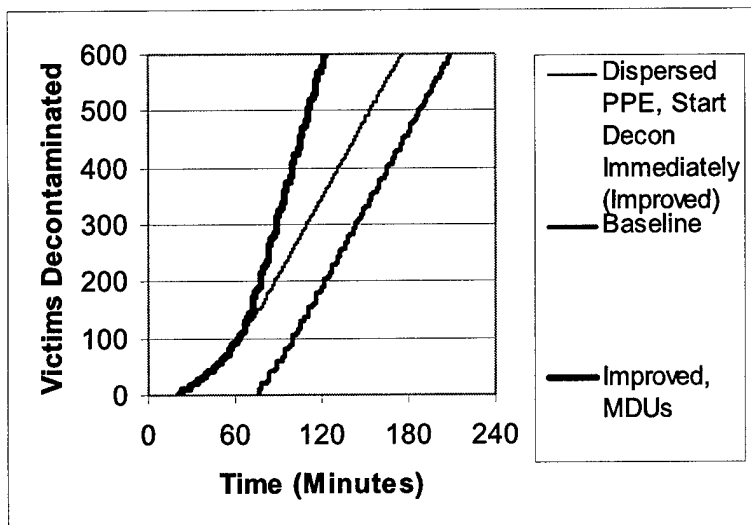


Figure 5.7 Comparison of Improved Option (Dispersed Equipment and Starting Technical Decontamination Immediately), Baseline, and the Improved Option with MDUs.

The results from these multiple options, along with their corresponding acquisition costs and cost per additional casualty avoided can be seen in Table 5.6 below.

	Parathion		Total Cost	Cost/ Additional Casualty	
	High	Low		Parathion (H)	Parathion (L)
LACoFD Baseline	174	95	NA	NA	NA
LACoFD Multi Cache	177	99	\$ 150,000	\$ 52,505	\$ 35,706
LACoFD No Tents/Single Cache	178	99	0	--	--
LACoFD No Tents/Multi Cache	182	105	\$ 150,000	\$ 19,092	\$ 14,704
LACoFD Dispersed PPE/Start Immediately	186	112	\$ 70,000	\$ 5,904	\$ 4,070
LACoFD Dispersed PPE/Immediate Start/MDU	192	119	\$ 70,000	\$ 3,920	\$ 2,892

Table 5.6 Casualties Avoided per Option, Corresponding Acquisition Costs, and Cost per Additional Casualty avoided.

The multiple cache option costs \$150,000 for extra vehicles, trailers and equipment, but it only helps avoid three or four casualties. This is about the same number of casualties avoided for no cost if LACoFD just stopped waiting to use the tents, but still relied on a single cache for the other equipment,

such as PPE. Dispersing the PPE to each fire company, for a cost of \$70,000, and starting immediately (not waiting for the tents) brings the highest numbers of casualties avoided, whether using the mass decontamination units (MDUs) or not—twelve to seventeen avoided casualties without the MDUs, and eighteen to twenty-four avoided casualties with the MDUs. For the cost of \$70,000 and with no-cost changes to its doctrine, the County can reduce their response time and avoid the most casualties of the listed options. This last option also provides a lower cost per casualty avoided over the other options.¹⁹³

LAFD Options

In the downtown Los Angeles area, where there is a larger concentration of fire stations, the same advantage of dispersing equipment can be seen. LAFD has already dispersed their PPE, and has their tents located in the downtown area. Because LAFD can bring 10 strike teams within approximately 50 minutes to an incident scene in the downtown region, they have a greater ability to provide emergency services to a chemical terrorist incident in a short period of time. The starting time for technical decontamination is also shorter than for LACoFD, since the LAFD has less distance to bring their personnel and equipment to the scene in this downtown scenario. The high throughput capacity of LAFD in the downtown area, thanks to the large number of firefighters, would lead to a bottleneck in gross decontamination in the 1,000 casualty scenario if the incident commander relied on a single gross decontamination station.

As can be seen in Figure 5.8 below, the main difference between the LAFD baseline and improved (i.e., immediate start, dispersed PPE, and increase in gross decontamination units) options is that the baseline technical decontamination does not start immediately, rather it starts fifteen minutes later due to the tents being erected. Both the decision to start immediately and the shortfall in gross decontamination could easily be fixed by no-cost doctrine changes. These no-cost options help avoid an additional seven or nine casualties, as seen in Table 5.7 below.

¹⁹³ The no tent/ single cache option has no cost involved, however it only avoids four casualties over the baseline, while the dispersed PPE/immediate start/MDU option avoids 18 to 24 casualties.

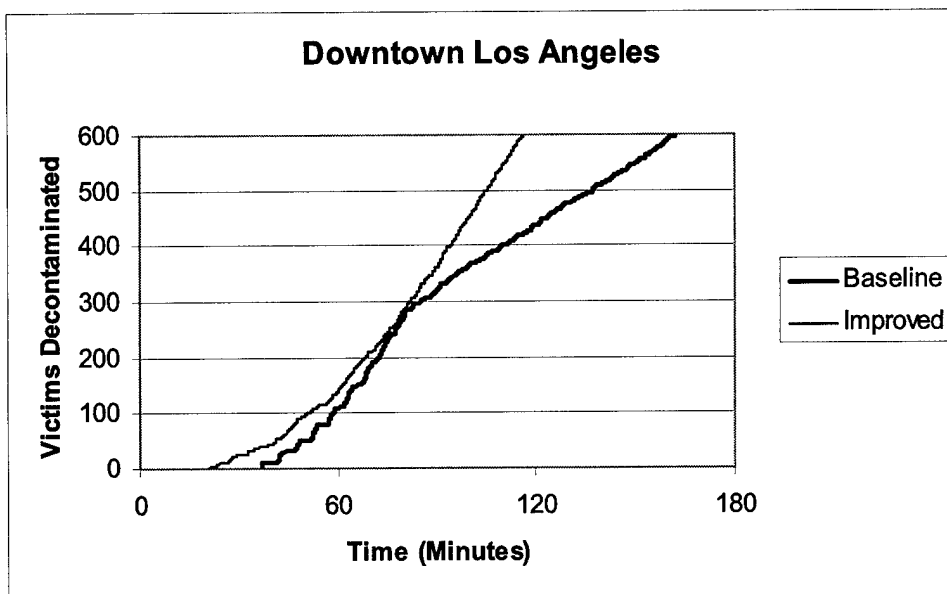


Figure 5.8 Comparison of Baseline Capabilities and the Start-Immediately "Improved" Option in Downtown Los Angeles by LAFD.

	Parathion	
	High	Low
LAFD Downtown Baseline	189	114
LAFD Downtown Improved Option	195	123

Table 5.7 LAFD Casualties Avoided for the Baseline and Improved Option—Starting Immediately with Dispersed PPE, Rather than Waiting to Set Up Tents.

Alternative Locations

A chemical terrorist incident could take place anywhere in Los Angeles County, and not just in the city's downtown area or in some hypothetical location represented in the earlier analysis for LACoFD. Depending on the locations of the incident, the cache of equipment, the fire personnel, and the mass decontamination units, times of travel might vary. For further analysis of the improved option, six locations throughout the Los Angeles were chosen, based on the potential for terrorist attacks as well as to represent geographic variety. The Los Angeles International Airport (LAX), the Los Angeles downtown area, the Port of Los Angeles, and the City of Industry are all possible targets for attack due to their high visibility, or, for the latter two locations, because of the presence of toxic industrial chemicals in those areas. Santa Monica and Pomona were chosen as two sites that might

have a terrorist attack, but which were either relatively close (Santa Monica) or further away (Pomona) to the center of the County.

Figure 5.9 below shows the response at each of these six locations for the baseline, multiple cache, and improved options. The improved option in each case leads to an improvement from the baseline or utilizing multiple caches of equipment in terms of quicker start and end times. In the case of downtown Los Angeles with its increased number of firefighters and cached equipment, and of LAX where two MDUs are located, the improved option offers less of an advantage than the other four locations. These other locations, which are further away from the MDUs and cached equipment, the improved option has a much more dramatic affect upon the start and finish of the technical decontamination process. In terms of casualties avoided, which can be seen in Table 5.8 for an exposure to parathion, the improved option can lead to six up to nine casualties avoided in downtown Los Angeles or LAX, or a more dramatic change of fourteen up to twenty-two casualties avoided in the other four locations.

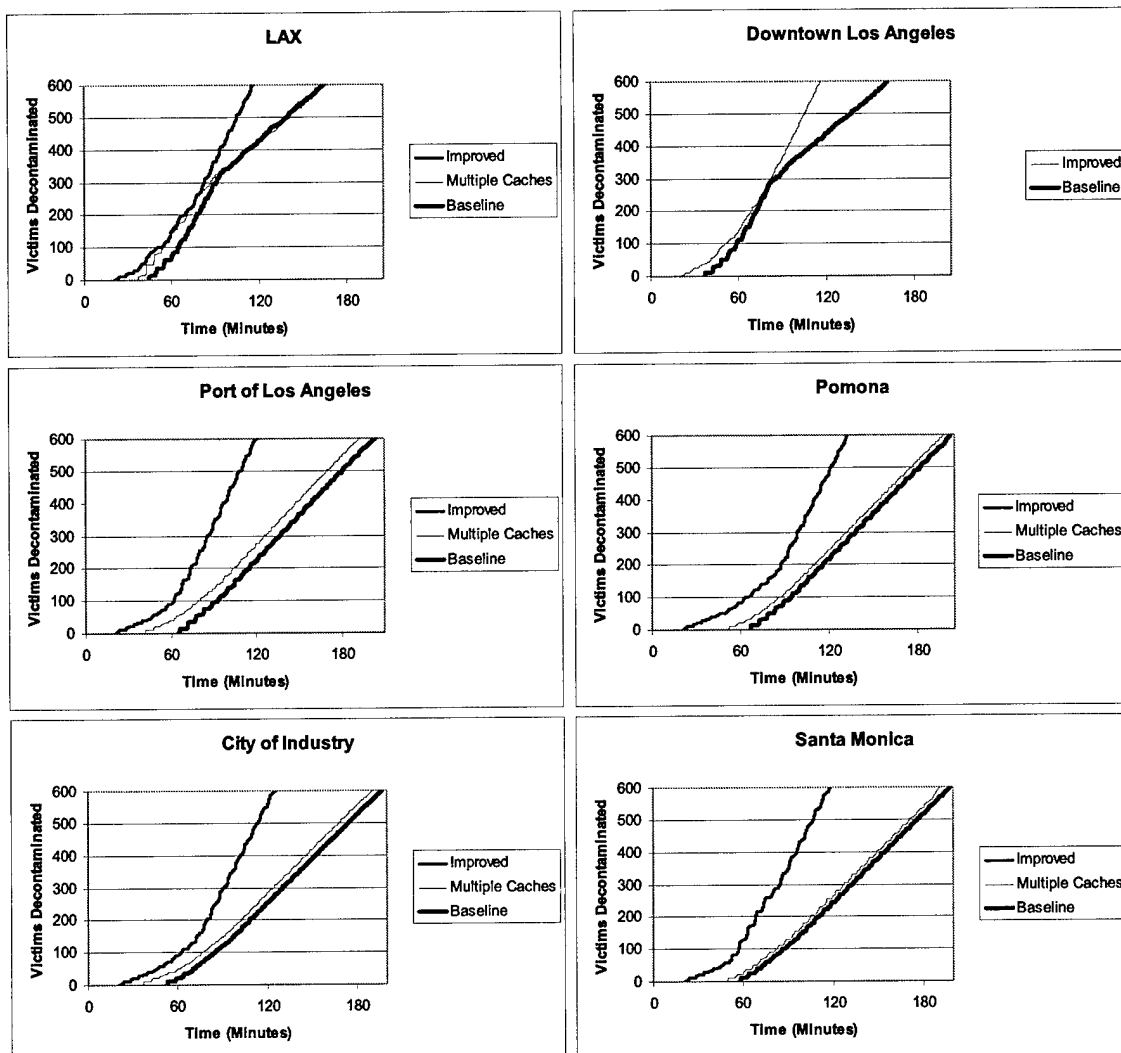


Figure 5.9 Comparison of Baseline, Improved, and Multiple Cache Options for Multiple Locations—Los Angeles International Airport (LAX), Downtown Los Angeles,¹⁹⁴ Port of Los Angeles, Pomona, City of Industry, and Santa Monica.

¹⁹⁴ The Downtown Los Angeles graph does not include the multiple cache options since a cache of equipment is located in the downtown area, leading to results that are identical to those of the baseline.

Location & Option	Parathion	
	High	Low
LAX Baseline	188	114
LAX Multiple Caches	189	115
LAX Improved Option	195	123
Los Angeles Downtown Baseline	189	114
Los Angeles Downtown Improved Option	195	123
Port of LA Baseline	176	97
Port of LA Multiple Caches	179	102
Port of LA Improved Option	192	119
Pomona Baseline	176	97
Pomona Multiple Caches	178	99
Pomona Improved Option	190	116
City of Industry Baseline	178	99
City of Industry Multiple Caches	181	104
City of Industry Improved Option	191	118
Santa Monica Baseline	176	98
Santa Monica Multiple Caches	179	101
Santa Monica Improved Option	193	120

Table 5.8 Casualties Avoided in Response to a Parathion Exposure by Location and Response Option

Traffic

As anyone who has lived in Los Angeles knows, heavy traffic is a part of daily life. A terrorist incident could occur at any time throughout the day, but terrorists might time their attack such that it would cause the most casualties and/or provide the greatest difficulties for an effective emergency response. Depending on the time of day, there may be significant delays, even for emergency equipment traveling to the scene with lights and sirens. For the purpose of this dissertation and subsequent simulations, the assumption for heavy traffic used in the chemical terrorism planning model was to double the time for each of the emergency response units to arrive at the scene of the incident.¹⁹⁵

The doubling of travel time to the incident site due to heavy traffic would mean that gross decontamination would start five minutes later than the previous scenarios. The subsequent fire companies would also take twice as long in arriving to the scene. Table 5.9 below shows how the

¹⁹⁵ While heavy traffic may result in less or more travel time than that used in the model, the doubling of the travel time illustrates the problem that heavy traffic can cause.

delay caused by heavy traffic results in just a small change in the casualties avoided if the chemical was chlorine or phosgene, since those two chemicals take more time before physiological damage occurs. However, if the chemical used was hydrogen cyanide (not shown in Table 5.9), the delay to the first emergency responders arrival would most certainly lead to the inability to save lives—those exposed to a lethal dose of hydrogen cyanide would be dead upon the arrival of the responders. The small difference between the casualties avoided with only one engine providing gross decontamination with average and heavy traffic is due to there only being five minutes of difference in the overall time—the traffic causing the first engine to arrive five minutes later. The other options with two or three engines providing gross decontamination cut the overall time in half of the original option.

	Average Traffic			Heavy Traffic		
	CL & CG		Time (Minutes)	CL & CG		Time (Minutes)
	High	Low		High	Low	
1 Gross Decontamination	127	65	156	127	64	161
2 Gross Decontamination	138	74	86	135	72	93
3 Gross Decontamination	141	76	63	138	74	72

Table 5.9 Comparison of Casualties Avoided for a Normal Response and One Delayed by Traffic to a Chlorine (CL) or Phosgene (CG) Scenario with One to Three Gross Decontamination Stations for the On-Scene Victims: 1,500 Sent Through Gross Decontamination, 300 Contaminated Victims.

For the baseline, this meant the cached equipment took twice as long to arrive to the scene of the attack before emergency responders started technical decontamination. Splitting the centralized cache into several locations helped cut the required time, but it was still twice as long as in the earlier simulations. The improved option—dispersing the PPE to each of the fire companies and having them start immediately by not using tents for modesty—was also delayed by the units arriving later than before, but they were then able to immediately start the technical decontamination process.

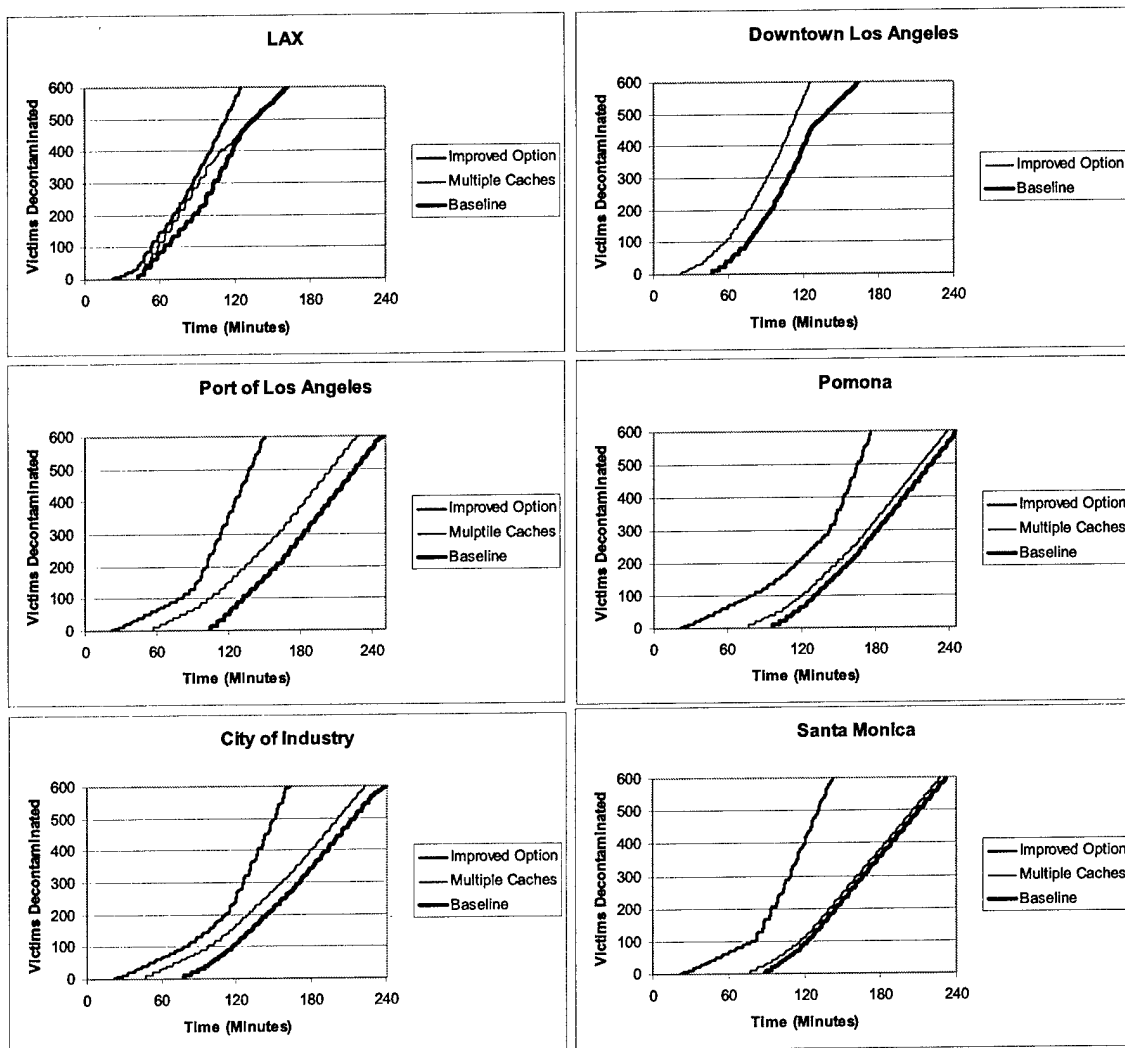


Figure 5.10 Comparison of the Improved, Multiple Caches, and Baseline Options across Multiple Locations when Performed with Traffic that Doubles the Travel Time

As can be seen in Figure 5.10 above and the casualties avoided detailed in Table 5.10 below, the greatest difference is realized in the locations farthest away from the caches (the Port of Los Angeles, Pomona and Santa Monica).¹⁹⁶ While heavy traffic will increase the time for the response units to arrive, the fact that the first units can start decontamination procedures right away under the improved options allows the responders to start immediately avoiding casualties who would otherwise have died or suffered injury. The friction caused by traffic would lead to further delays for centralized or

multiple-cached equipment to arrive. Putting the minimum required equipment directly in the hands of the emergency responders allows them to immediately start the decontamination process without traffic causing further problems. Thus the improved option is more robust in dealing with time delays, such as traffic.

Location & Option	Traffic			
	Average		Heavy	
	Parathion		Parathion	
	High	Low	High	Low
LAX Baseline	188	114	186	110
LAX Multiple Caches	189	115	188	113
LAX Improved Option	195	123	193	121
Los Angeles Downtown Baseline	189	114	184	107
Los Angeles Downtown Improved Option	195	123	192	119
Port of LA Baseline	176	97	165	84
Port of LA Multiple Caches	179	102	171	91
Port of LA Improved Option	192	119	186	110
Pomona Baseline	176	97	165	84
Pomona Multiple Caches	178	99	168	87
Pomona Improved Option	190	116	181	104
City of Industry Baseline	178	99	169	88
City of Industry Multiple Caches	181	104	173	94
City of Industry Improved Option	191	118	183	108
Santa Monica Baseline	176	98	169	88
Santa Monica Multiple Caches	179	101	170	90
Santa Monica Improved Option	193	120	187	114

Table 5.10 Casualties Avoided in Response to a Parathion Exposure by Location and Response Option for with Traffic (Double the Response Time) and Normal Traffic.

Helicopter

An additional option to speed response is to use a heavy lift helicopters to bring the equipment cache and/or an additional MDU to the incident scene. This could in some situations deliver the equipment cache faster to the scene (avoiding Los Angeles' traffic) as well as provide additional

¹⁹⁶ The LAX and downtown Los Angeles scenarios have less of a difference than the other locations. For LAX this is a result of the MDUs already located at the airport, which would not be affected by traffic. In downtown Los Angeles, more strike teams can arrive en masse, even with heavy traffic than in other the other locations, resulting in an ability to technically decontaminate more individuals in less time.

decontamination capability.¹⁹⁷ Both LAFD and LACoFD use helicopters of the heavy lift variety¹⁹⁸ needed to transport equipment. However, the current helicopters are used for other fire missions—transporting personnel and fire retardant to fires throughout the county. Those that carry fire retardant or equipment are not used to move personnel. The heavy lift helicopters carry a water tank capable of holding 2,600 gallons, which requires several hours of effort to remove in order to carry cargo such as the MDU or equipment cache. Thus, to ensure that a helicopter was ready at all times for a terrorist incident, either LAFD or LACoFD would need to have an additional helicopter. Alternatively, the fire departments could work out an agreement with the California Air National Guard to use one of their helicopters, but these helicopters are also used for alternative missions, so they might need an additional helicopter specifically for terrorism response.

The heavy lift helicopters have a large rotor disk, requiring 100 feet diameter of clearance to land. This space requirement can make landing difficult in an urban area and especially in the downtown district. The space requirement can be alleviated if the equipment is carried by a 300 foot cable below the helicopter, allowing the helicopter to deliver the equipment without landing. However, this method also forces the helicopter to fly more slowly. The time required for the helicopter to mobilize and then fly to most locations in Los Angeles is 25-40 minutes if the equipment were carried close to or inside the helicopter (requiring the helicopter to land) or 35-50 minutes if the equipment were carried by cable under the helicopter.

The acquisition cost for the Sikorsky S-64 Sky Crane helicopter would be approximately \$16 million. At least \$1.4 million per year would be needed for the additional crew members (pilots, load specialist, and mechanic). An additional \$200,000 would be needed to purchase an extra MDU that would be transported by the helicopter. This option would also require training on the MDU, since the

¹⁹⁷ If the helicopter only brought the current equipment cache, the performance still would not be as high as the improved option from Chapter Five. Thus additional decontamination capability, such as an additional MDU, would be needed in this case as well.

¹⁹⁸ The two fire departments use modified Sikorsky S-64 Sky Cranes as their heavy lift. LAFD owns their Sky Crane, while LACoFD contracts the use of a Sky Crane along with the U.S. Forestry Department.

firefighters of LAFD and LACoFD are not all trained to use the MDU system.¹⁹⁹ Figure 5.11 shows how this option affects the response performance, if the helicopter brought an additional MDU to an incident site in downtown Los Angeles or further out in the county in Pomona with normal and heavy traffic.

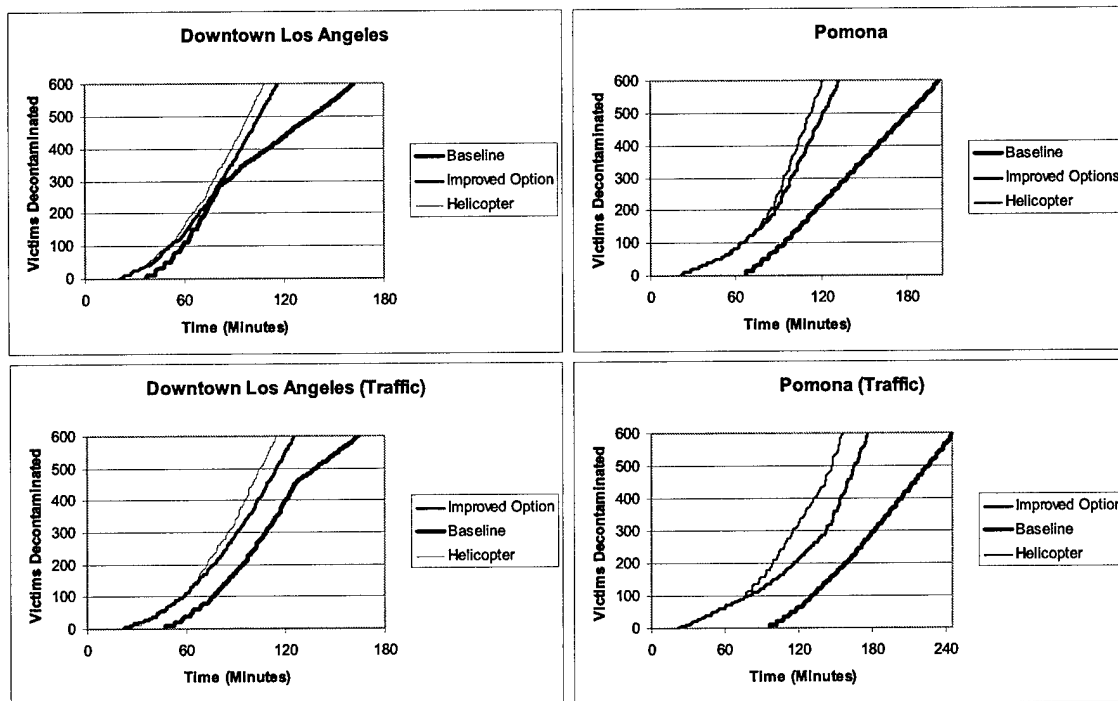


Figure 5.11 Comparison of Improved Options, Helicopter Bringing Additional MDU and the Current Baseline in Downtown LA and Pomona with and without heavy Traffic; Psychosomatic Victims Triaged at 25 Percent False Positive.

Location & Option	Normal		Traffic	
	Parathion		Parathion	
	High	Low	High	Low
Downtown LA Baseline	189	114	184	107
Downtown LA Improved Option	195	123	192	119
Downtown LA Improved & Helicopter	197	126	193	120
Pomona Baseline	176	97	165	84
Pomona Improved Option	190	116	181	104
Pomona Improved & Helicopter	191	117	185	109

Table 5.11 Casualties Avoided for Improved Options, Helicopter Bringing Additional MDU and the Current Baseline in Downtown LA and Pomona with and without traffic; Psychosomatic Victims Triaged at 25 Percent False Positive.

¹⁹⁹ Currently only the LAFD firefighters assigned to respond to the Los Angeles and Ontario International Airports are trained to set up the MDU.

The addition of a helicopter bringing an additional MDU provides additional decontamination capacity, but it would not be ready for almost an hour after the chemical release. As Table 5.11 above shows, the addition of the helicopter leads to 1-3 additional casualties avoided in downtown Los Angeles above the improved option, and leads to 1-5 additional casualties avoided in Pomona (4-5 more in high traffic). Adding a helicopter would cost an initial \$17.6 million which would provide 1-5 additional casualties avoided above the low-cost \$70,000 option, but at a cost per casualty avoided of \$17.6 million to \$3.52 million. Helicopters, like the Sikorsky S-64 Sky Crane are leased from vendors during the wild fire season to expand capacity. Leasing a Sky Crane costs approximately \$3,000 per hour, but the helicopter may not be always ready and waiting—it might be leased out to another group for other purposes. While time is also critical in fighting a fire, it is not as time sensitive as responding to chemical terrorism (i.e., no lives may be lost in a wildfire response if the helicopter arrives 30 to 60 minutes late). For effective use in response to a chemical terrorist attack a helicopter and crew would need to be ready for deployment at all times. Thus leasing a helicopter for instant deployment would be more expensive than purchasing the helicopter.

Chemical Detection/Identification

Chemical identification is an essential element in the response process. Timely identification is needed in order for emergency responders to make the appropriate decisions for decontamination and providing emergency medical services. Currently it is the responsibility of the HazMat teams to provide chemical detection and identification for routine chemical accidents as well as for potential chemical terrorism incidents. Chemical identification technology, although a high priority for both the Department of Defense and the Department of Homeland Security, is still not at a level where simple to use, low-cost, fast detectors are available to detect and identify a broad range of chemical warfare and toxic industrial agents. As a result highly trained HazMat technicians use multiple techniques to identify the chemical(s) employed in the incident.

A rapid, successful identification process requires the timely arrival of a HazMat team at the incident scene. After arrival and a quick briefing by the incident commander, the HazMat team starts the chemical identification process. The time required to identify the chemical depends on the chemical used, the means of dissemination, as well as on the equipment and training of the HazMat team. A chemical, such as chlorine, could be quickly identified by smell and then verified through identification gear. Other chemicals, such as parathion, phosgene, and hydrogen cyanide may demand a more complex identification process. Using current technology, the identification process can take 30 to 60 minutes for the four selected chemicals.²⁰⁰

If the HazMat crew does not arrive at the scene for 20 minutes and then takes another 30-60 minutes for identification, the incident commander may be acting for approximately 50-80 minutes after the attack without knowing precisely which chemical(s) were used by the terrorists.²⁰¹ At the 1995 Tokyo incident, it took approximately three hours before the chemical sarin was identified.²⁰² A greater emphasis on training and equipment for HazMat technicians has been made in the wake of the Tokyo incident, but there remains no simple all-purpose identification technology.

Slow identification forces the incident commander to make difficult decisions early in the response without a full understanding of the situation. This will require the response community to come up with protocols for how to treat mass casualties contaminated with an unknown material. If the commander were to wait until the chemical was identified before responding with technical decontamination and emergency medical services, then more individuals could die or be injured. Figure 5.12 below represents the two scenarios at two locations (Downtown Los Angeles and the Port of Los Angeles) of starting right away or waiting until the HazMat team identifies the chemical used, and Table 5.12 shows casualties avoided for each case. In both examples the improved option allows for

²⁰⁰ The slow detection time is yet another compelling reason why purchasing numerous cyanide antidotes at this time may not be a good investment, since the victims would be already dead by the time the chemical was identified.

²⁰¹ If a toxic industrial chemical site, train tank, or tanker truck was targeted to create the release the chemical might be more quickly identified.

²⁰² National Research Council, Institute of Medicine, *Chemical and biological terrorism: Research and development to improve civilian medical response*. Washington, DC: National Academy Press, 1999, 44.

approximately 100 or more individuals to be technically decontaminated before the chemical is identified. However, because most of the responding units in the "wait on identification" are assembled and ready to begin technical decontamination as soon as identification is performed, they quickly come in parallel with the improved response. The downtown Los Angeles scenario with its numerous responders appears almost to converge, but in reality quickly comes into parallel with the improved option.

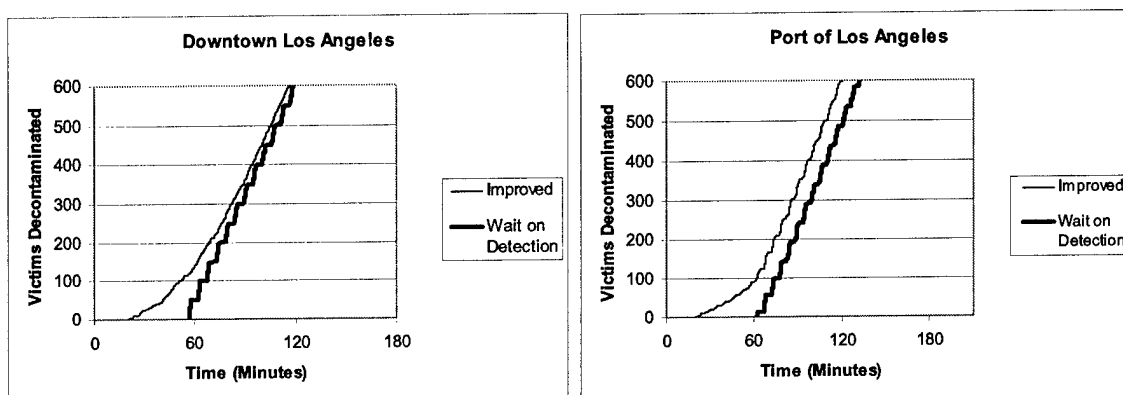


Figure 5.12 Comparison of the Improved Option in Downtown Los Angeles and Port of Los Angeles when Starting Immediately or Waiting Until Chemical is Identified by HazMat.

	Parathion	
	High	Low
Improved Response - Downtown Los Angeles	195	124
Wait on Identification - Downtown Los Angeles	189	112
Improved Response - Port of Los Angeles	192	119
Wait on Identification - Port of Los Angeles	186	109

Table 5.12 Casualties Avoided for Improved Options in Downtown Los Angeles and Port of Los Angeles when Starting Immediately or Waiting Until After Chemical is Identified by HazMat.

Given the lack of simple-to-use detection gear, incident commanders should take an approach that focuses on the preservation of life. This can be done by looking at alternative indications that the victims have been exposed to a specific chemical (e.g., symptoms the victims may be exhibiting, what the air may smell like, dispersal device, etc.) and then basing the response on these indicators. However, the HazMat team should make their more accurate, technical determination as quickly as possible. The incident commander can then make changes to the response plan based on the

guidance of the HazMat team. It would be better to start the decontamination process, even if it were found eventually to be unnecessary, than to wait until a positive identification of the chemical was made. Policy makers in Los Angeles should put pressure on federal research and development institutions to fund the creation of simple-to-use detection and identification equipment that can detect/identify toxic industrial chemicals, as well as chemical warfare agents.

Training for On-Scene Response

Training is needed to maintain the baseline capability. Among key Los Angeles firefighters and emergency responders, there is disagreement as to how much improvement can be gained from enhanced or improved training. However, all agree that without consistent and repeated training, or use of the skills in an operational environment, the skills and corresponding knowledge will atrophy. As discussed previously in this chapter, LAFD spends approximately \$2.16 million per year on hands-on counter-terrorism training and LACoFD spends \$610,000 for two two-hour sessions per firefighter. However, the counter-terrorism coordinators for both of these organizations do not feel the present level of training is sufficient to maintain the skills needed to respond to an actual event, a view also shared by LA City Councilman Jack Weiss.²⁰³

While hands-on skill training is the most effective method of training, there are other methods that could help maintain the skill base. The Federation of American Scientists, in their report on counter-terrorism training, sees distance learning as inexpensive but effective.²⁰⁴ However, most fire stations have few computers, which are necessary to carry out this type of training.²⁰⁵ The acquisition cost to LAFD alone to purchase one additional computer per station for training purposes, assuming \$1000 per computer, would be \$103,000. This does not include maintenance, software, Internet

²⁰³ Jack Weiss, *Preparing Los Angeles For Terrorism: A Ten-Point Plan*, October 2002, p.20

²⁰⁴ Henry Kelly, et al, *Training Technology Against Terror: Using Advanced Technology to Prepare America's Emergency Medical Personnel and First Responders for a Weapon of Mass Destruction Attack*, Federation of American Scientists, 2002. Internet: http://www.fas.org/terrorism/wmd/docs/wmd_resp.pdf.

²⁰⁵ Most single company stations have only one computer which is used by for administrative purposes. Larger stations often do not have additional computers, and if so, they are also used for administration.

connectivity, installation, or the cost of the training itself (if any). Additionally, if there were only one computer, the training only could be done individually. A low cost alternative is to create videos that walk step-by-step through the chemical terrorism response process. A similar suite of videos was created by Los Angeles Sheriff's Department (LASD) for terrorism training at a production cost of approximately \$20,000 per 30 minute video.²⁰⁶ The LASD suite does not cover decontamination and emergency medical services in the depth required for responding to a chemical attack. However, LAFD and LACoFD could work with LASD to create a low-cost video. All fire stations throughout Los Angeles have videotape and DVD players and plenty of recliners facing a large-screen television. This video would not substitute for hands-on training, but could keep skills fresh in the minds of the firefighters if reviewed on a regular basis between training exercises. Videos, as well as other didactic processes (e.g. web-based training), are effective means for providing refresher training and certification at the entry level,²⁰⁷ and are used regularly in most fire departments. The creation and use of low-cost training aids would help keep the knowledge and skills needed to respond to a chemical terrorist incident from atrophying. Without regular training on these skills the overall response to such an event would be slower and could result in greater loss of life or increase in injuries sustained.

Paramedics and Triage

The model includes paramedics not only providing triage before technical decontamination, but also providing emergency medical services after decontamination. Depending on the nature of the chemical to which the victims were exposed the paramedics might provide an antidote, oxygen, or other medical services. Figure 5.13 below shows the time required for both technical decontamination and the subsequent emergency medical services according to current doctrinal and organizational policies and using the current equipment for both the baseline and improved options.

²⁰⁶ Such an endeavor could take advantage of LASD's in-house video production unit.

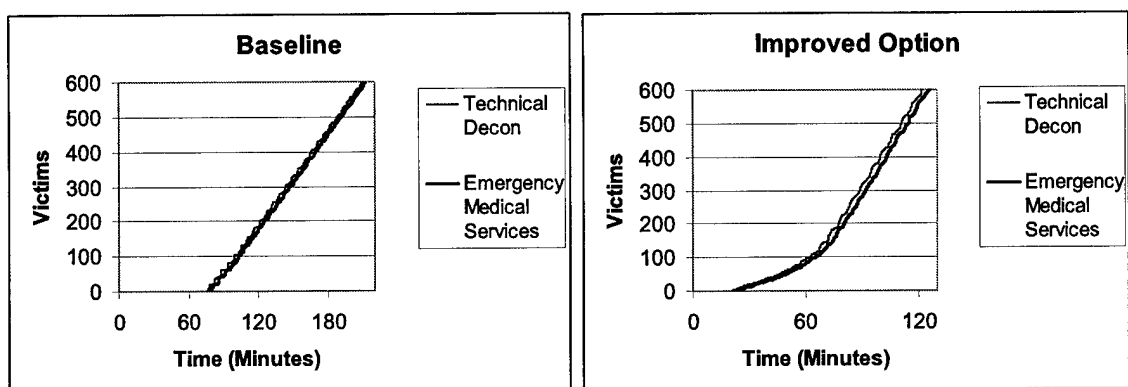


Figure 5.13 Technical Decontamination and Subsequent Emergency Medical Services

As can be seen in Figure 5.14, the two lines are practically the same, except that the emergency medical services take approximately three to four more minutes than the technical decontamination. Given this modest difference between the time for technical decontamination and subsequent emergency medical services, in this dissertation, the time for completion of emergency medical services has not been shown.

As discussed in Chapter Four, the chemical terrorism planning model includes psychosomatic victims and the actions of paramedics (performing triage and providing emergency medical services). The assumption noted in Chapter Four was that 80 percent of the victims in the full model would be psychosomatic. This means that in addition to the 1,000 contaminated victims in the model, there are an additional 4,000 worried well as well. Chapter Four also described how paramedics would not always be able to differentiate between actual victims and the worried well, so the baseline to this point has included 25 percent of the worried well being treated as symptomatic victims—this doubles the number of on-scene victims receiving technical decontamination and emergency medical services. While paramedics undergo training for triage and chemical response, when confronted with mass casualties and worried well, most of whom have gone through initial gross decontamination as a safety mechanism, the paramedics may be less able to readily identify who is truly contaminated and who is

²⁰⁷ Interview with Assistant Fire Chief Hank Blackwell, Sante Fe County Fire Department, October 30, 2003. Chief Blackwell is the author of *The Effectiveness of Video Training in the Fire Service*, National Fire Academy, Emmitsburg, MD: 1993.

simply a worried well. Triage may be based on questions relating to exposure rather than on simply looking for symptoms—many of the symptoms may not be exhibited until hours later if victims were exposed to chlorine or phosgene.

False Positives & Worried Well

In the model scenario 300 contaminated casualties remain on scene along with 1,200 worried well. The time to provide technical decontamination and emergency medical services to the truly contaminated victims depends on how accurately paramedics can identify them. This may not be easy when many of the worried well could be psychosomatic with self-induced symptoms that might mimic those of the truly contaminated victims. Yet for every worried well that is deemed “symptomatic” during triage by the paramedics (thereby becoming a false positive), the total time required for technical decontamination and emergency medical services is increased, which, depending on the chemical can lead to greater casualties among the contaminated victims.²⁰⁸ Figure 5.15 below shows how the increase in the percentage of false positives (worried well deemed to be contaminated victims) leads to fewer casualties avoided in all cases.

²⁰⁸ As discussed in Chapter Four false negatives are also an issue that is individuals who are contaminated but deemed “non-symptomatic” by paramedics. According to discussions with senior paramedics in the Los Angeles area they would prefer to err on more false positives than to have false negatives. The false negative potential is real, and paramedics (as well as medical professionals at hospitals) would need to hold and continue to observe all individuals on-scene and at hospitals to determine if they indeed were contaminated and symptomatic.

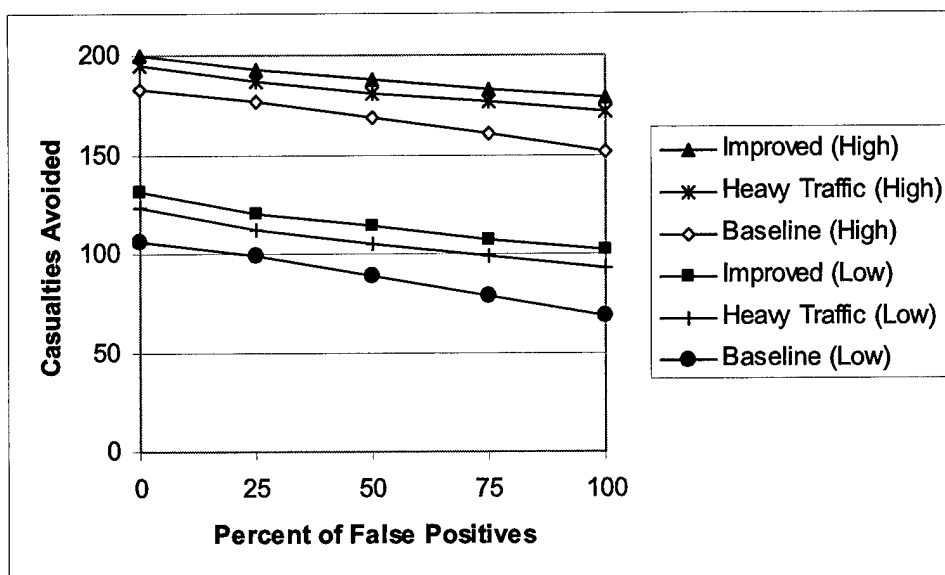


Figure 5.15 Varying Effectiveness of Triage for Improved, Heavy Traffic (Improved Option), and Baseline versus Percentage of worried well False Positives for Both High and Low Postulated Values of Casualties Avoided

Improvements in triage can lead to more casualties avoided, though do not provide a substitute for improvements in technical decontamination. As can be seen in Figure 5.15 above, perfect triage (i.e., zero percent of false positive) at the baseline level is the same as the performing no triage at all (i.e., 100 percent false positives) with the improved option. Improvements in both triage and response can lead to even more casualties avoided. While we have assumed 25 percent false positives, none of the paramedics or hospital experts consulted for this dissertation could give a reliable estimate of the number of triaged false positives. That said, it is clear in Figure 5.15 that efforts to triage that successfully reduce false positives could lead to avoided casualties.²⁰⁹

False negatives are of greater concern to paramedics, since they would rather provide services to individuals that do not need medical services, than miss a victim and let him or her suffer unnecessarily.²¹⁰ In order to avoid false negatives during the triage process, paramedics will err on the side of caution. This approach will generate false positives, which, as we have seen, will slow the

²⁰⁹ As stated previously during the triage process it is likely for there to be some false negatives. However, even if paramedics (or hospital personnel) err on the side of more false positives in order to avoid false negatives, based on Figure 5.15, it is still better to go that route than conducting no triage at all.

²¹⁰ This statement is based on discussions with the LACoFD paramedic division.

medical and decontamination process, leading to fewer casualties avoided. Improvements in triage can help reduce both false positives and false negatives.

Triage can be improved through improved training or by point chemical detection on the victims. As stated above, LACoFD paramedics received two hours per month for training on response to chemical events. But they only train every other year on basic triage skills. Training is expensive and is also an area that is not covered by federal grants—the locality is responsible for the training of their personnel.²¹¹ The video option described above is one option for maintaining training levels and/or helping sharpen triage skills throughout the year. Without training, whether hands on, through videos or other means, to refresh skills the ability of paramedics recognizing symptoms of chemical exposure may diminish and the likelihood of more false positives and negatives may occur during actual triage.

The use of chemical point detectors is another means to help determine who is indeed contaminated and who is not. As of this writing, there is no universal chemical point detector that can quickly identify whether an individual is contaminated or not for all toxic industrial chemicals and chemical warfare agents. Trained HazMat personnel use a suite of detection gear to identify unknown chemicals, and may arrive on the scene after triage has begun. While a simple handheld detection device is not yet available, it would not need to be as sophisticated as the HazMat detectors to support paramedics in triage. Paramedics do not need to identify the chemical, rather they need only determine if a victim is contaminated. This is a much lower level of specificity. If and when such a simple device is developed, it would be of great assistance in triage, as well as after the decontamination process to help determine if the victims are fully decontaminated.

²¹¹ Grants from the Office of Domestic Preparedness typically cover exercises, but not necessarily basic training.

Hospitals

As discussed in Chapter Four, the limited historical data available—both chemical terrorist incidents like the 1995 Tokyo incident as well as non-terrorist mass casualty incidents—suggest that most casualties will leave the scene of an incident and go directly to hospitals.²¹² This means that the hospitals need to have the capability to conduct mass casualty triage and decontamination. At this time hospital emergency departments do not have the technical ability to detect or identify chemicals (neither toxic industrial chemicals nor chemical warfare agents), and thus rely on local HazMat to provide this information. As mentioned previously in this chapter, the identification process takes time and casualties will have presented themselves at the hospitals before their emergency departments will be notified of the identity of the chemical.²¹³ As a result, hospitals need to be ready to deal with an unknown chemical for up to an hour before notification.

In preparation for the 2000 DNC, the Los Angeles County Department of Health Services provided training for 50 hospitals on triage, decontamination and emergency medical procedures for a chemical event. As discussed in Chapter Four, all hospitals in Los Angeles are required to have the capability to decontaminate one person, with most having a single shower located somewhere in the hospital for this purpose.

Hospital Decontamination Equipment

Los Angeles has access to Health Resource and Services Administration (HRSA) grants that can provide up to \$20,000 to hospitals for the installation of a simple warm-water decontamination system that must process at least 50 people per hour.²¹⁴ The hospitals also need PPE in order to protect their emergency personnel from possible secondary exposure to the chemical from the

²¹² The number of casualties self-evacuating to hospitals would also be dependent on the arrival time and response of the emergency personnel on-scene and the level of incapacitation of the victims (i.e., the type of chemical and level of exposure).

²¹³ Notification of the identity of the chemical will most likely be broadcast to the area hospitals by the Los Angeles County health department after first being informed by the HazMat team.

²¹⁴ *Hospital Bioterrorism Preparedness*, PowerPoint presentation from the County of Los Angeles Emergency Medical Services Agency. Confirmed through discussion with LA County's Disaster Medical Officer.

victims.²¹⁵ They will need splash suits, boots, gloves, and mask/breathing apparatus. The county recommends a self-powered air filter mask system. The acquisition cost for this combination of gear is approximately \$1,000 per complete set,²¹⁶ and the same HRSA grant provides up to \$10,000 per hospital for PPE. The cost to install the decontamination system may be more than the grant amount; as of this writing not all hospitals have agreed to take the money.

If a hospital does accept the grant, it has great flexibility as to where it can build the decontamination system and the number of showers to be included, as long as the total decontamination rate is equal or greater than 50 per hour. Hospitals taking the grant money will need to ensure that their decontamination system has more than four shower heads (assuming that each person showering takes the recommended five minutes to self decontaminate four showers would allow 48 people to decontaminate within the hour—two short of the goal). For each additional shower added to the system twelve additional people per hour could be decontaminated.

Hospital Organization/Doctrine

A low or no-cost option to improve decontamination services at hospitals would be to bring fire companies to the hospitals to assist in the process. Firefighters could provide gross decontamination (which, depending on the chemical, may be all that is required) and provide an additional technical decontamination station in order to service more victims quickly. Present doctrine has LAFD and LACoFD sending their personnel to the chemical incident scene and not to area hospitals. Pulling fire companies away from the scene to the area hospitals would delay triage and decontamination for the on-scene victims. Other metropolitan areas are considering an organizational solution to this problem. Mutual aid agreements, the same as are used to bring additional resources to incidents that exhaust

²¹⁵ Over twenty percent of the hospital staff at St. Luke's International Hospital, which treated 641 admitted patients from the Tokyo subway sarin incident, developed symptoms from secondary exposure. See Ohbu, Sadayoshi, et. al. "Sarin Poisoning on Tokyo Subway," *Southern Medical Journal*, June 1997. <http://www.sma.org/smj/97june3.htm>.

local resources, could be created where by outlying communities would provide fire companies to hospitals near the incident area to assist in decontamination. While these fire departments may not have the same PPE or training as LAFD or LACoFD, they could at a minimum provide gross decontamination.²¹⁷ This would free LAFD and LACoFD to focus on the scene of the incident. One fire company per hospital in the area of the incident could provide gross decontamination that otherwise may not be made available at the hospitals. In the case of exposure to hydrogen cyanide, chlorine or phosgene, the gross decontamination may be all that is needed before hospital personnel could treat the victims.

Another organizational/doctrinal option is to *a priori* select hospitals that will serve as decontamination centers. This option is often raised in dealing with disease outbreaks, such as smallpox, to ensure that not all hospitals in the area become contaminated. This option would reduce the costs of all hospitals building additional decontamination facilities, purchasing PPE, and conducting training. However, hospitals have no control over where a terrorist incident will take place. Nor would there be sufficient time in many cases to notify the victims, especially the convergent casualties, which hospital(s) are designed to accept contaminated patients.²¹⁸ Within minutes, the closest hospitals, as well as those most familiar to the victims, will receive contaminated patients. To then direct the victims to another hospital will only increase the time that they remain contaminated without medical services and add to the chaos. Thus it is necessary for all emergency-receiving hospitals to have decontamination facilities, as well as adequate PPE for their personnel and training on how to protect themselves and to provide services to contaminated victims.

²¹⁶ The large difference between the fire fighters low cost improvement of \$71 and the \$1,000 for hospital workers is the high cost of the respiratory protection equipment. Fire fighters have no need to purchase this equipment, since self-contained breathing apparatus is standard issue. Fire fighters also use their standard boots as well. The suits, gloves, and filters for the hospital respiratory protection equipment have a five year life cycle.

²¹⁷ There are 30 municipal fire departments in Los Angeles County other than LAFD and LACoFD spread throughout the county. The arrival time to the area hospitals would depend on the time of day (traffic) and distance to the hospitals. Mutual aid agreements and policies could be worked out to bring the closest engines to the hospitals.

²¹⁸ If emergency responders arrive at the scene before the convergent casualties leave, they could instruct these victims to which hospital to go. However, even if the first arriving fire company could be on scene in 4 to five minutes after the incident, many individuals may have already started to self-evacuate.

Hospital Training

Hospital emergency department personnel will need continuing training if they are to be fully prepared to respond when a chemical terrorist incident sends mass casualties streaming to their facility. Physicians who would oversee the medical response need to receive training so that triage can run effectively and the right life-saving measures can be taken quickly. Nurses and other emergency department personnel also need training to assist in the decontamination process. Security personnel will need to know how to recognize chemically affected individuals in order to stop their entry into the emergency rooms and direct them to decontamination areas outside the hospital.²¹⁹ Hospitals do not have chemical detectors to use in determining if incoming victims are contaminated, nor as stated previously are detectors at a technical level at this time to detect all possible chemicals which may contaminate incoming victims. Thus, hospital personnel need to recognize signs of contamination, as well as put their decontamination policies into play if/when a contaminated victim presents him- or herself at the emergency room. Should a contaminated victim arrive without notice, the hospital emergency room may be deemed contaminated and other victims and hospital that were not originally exposed at the site may need to leave the emergency room. This is, of course, dependent on the type of chemical and exposure to the chemical by the convergent casualty.

As noted above, the current HRSA grants that will go to area hospitals will provide \$30,000 for each hospital—\$20,000 for decontamination facilities and \$10,000 for PPE. However, the grant does not provide funding for training on decontamination procedures or on the use of the PPE.²²⁰ If the emergency department personnel are not trained they will not be able to effectively use the facilities or know how to don the personal protective equipment. Hospitals might explore mandating the training, or using incentives like providing continuing education credits for attending the training sessions. Without training, the hospitals put their personnel at risk of secondary exposure (i.e., not being able to gain the full protection of the PPE due to improper usage, or failure to use the PPE if they do not know how to

²¹⁹ Not all chemicals provided immediate visual clues, but hospital personnel could be trained for the visual clues of many likely chemicals and scenarios (e.g., several individuals arriving together all with shortness of breath).

operate it) and put their potential patients at risk of inefficient or ineffective treatment to chemical exposure.

Discussion of Hospital Advantage & Disadvantage

Hospitals provide the medical expertise needed to respond to the symptoms the victims will exhibit when exposed to chemicals; they also maintain limited stockpiles of antidotes such as atropine for nerve agent-like chemicals (organophosphates) as well as antidotes for cyanide.²²¹ Hospitals also have ventilators and oxygen supplies that can treat victims with respiratory conditions typical in exposures to chemicals like chlorine or phosgene. Hospitals have an advantage over the emergency mobile stockpiles of antidotes and equipment in that they can be cycled and replenished easily to reduce costly, expired medical supplies. The pharmaceuticals are also exposed to varying climatic conditions if stored on vehicles. These advantages of hospitals do not diminish the need for a mobile cache. A finite number of pharmaceuticals need to be ready for use at an incident scene, since in an incident there will be large numbers of individuals who are unable or choose not to proceed to a hospital on their own.

While hospitals may hold expertise in triage and emergency medical response, their weakness lies in areas outside the normal scope of their daily activities. Hospitals rarely deal with decontamination issues, and do not regularly train in this area. While a single fire department, such as LAFD, has 102 stations and is able to dictate training and readiness requirements, the hospitals located in the city of Los Angeles are separately owned and operated by a variety of entities (e.g., universities, private organizations, local government, etc.) and thus doctrinal or organizational changes may be more difficult to enact across them all. Another important difference is that many of the hospitals are profit-oriented business, and funding in counter-terrorism measures takes away from their profits.

²²⁰ The training would include how to assist in decontamination, the decontamination process of non-ambulatory victims, and the proper use of PPE. Fit testing for the PPE would also need to be done, to ensure the PPE will work effectively for the hospital personnel.

²²¹ The use of these antidotes is dependent on the hospital knowing to what chemical the victims were exposed. If this information is not provided, or provided late into the response, the full benefits of these antidotes may not be realized. Before hospitals know to what chemical the victims were exposed, they may be left to just treat symptoms with other means rather than antidotes.

Hospital Triage and Decontamination

At the hospital the model simulates triage taking place before technical decontamination in order to limit worried well being processed before those victims who are truly contaminated. Those performing triage at a hospital (or on scene) would make the determination of who is contaminated based on symptoms,²²² discussion with the victims,²²³ and other visual signs. In the model, the number of individuals at the hospital performing triage is a variable as well as the number of hospitals.²²⁴ Just as in the chemical terrorism planning model's on-scene simulation, those performing triage at the hospital most likely will not be perfect in their determination of who is genuinely contaminated. The assumption in this portion of the simulation, as in that of the on-scene paramedics, is for a 25 percent false positive rate among the psychosomatic victims—that is, 25 percent of the worried well are mistakenly deemed to be contaminated.²²⁵

The current triage and decontamination method taught to area hospitals by the Los Angeles County Department of Health Services (DHS) recommends one senior emergency department nurse or physician in PPE perform triage outside of the hospital's emergency room.²²⁶ No one coming to the hospital would be turned away. Rather, the individual performing triage would determine who should be prioritized to go through decontamination. Those deemed not contaminated or asymptomatic would be "held" in an area for observation.²²⁷ The triage and decontamination process would take place outside of the hospital to ensure that the emergency room and the emergency department personnel do not become contaminated by exposure to contaminated victims, or if notification of the chemical

²²² Depending on the chemical the symptoms may include difficulty in breathing, reddening of skin, nausea, dilated pupils, dizziness, headache, or eye irritation.

²²³ Exposure to chemicals, such as chlorine or phosgene may not have immediate symptoms, and emergency personnel may need to rely on questioning the individuals to determine exposure.

²²⁴ There are 88 emergency admitting hospitals throughout Los Angeles County, and convergent victims will not go to the same hospital. Rather, they will go to those closest and those with which they are most familiar. In the 1995 Tokyo subway incident convergent victims went to 12 hospitals.

²²⁵ Again this is an assumption of the author based on discussions with paramedics and county medical disaster physicians.

²²⁶ The recommendations from DHS are taken from interviews with DHS personnel as well as gathered from the LA County DHS presentation "Hospital Bioterrorism Preparedness", which describes the components of the HRSA grant.

²²⁷ Those under observation could go through decontamination after the high priority queue clears.

exposure comes too late, the process still would take place outside in order to limit the potential of secondary exposure and further contamination of the emergency room.

The current DHS endeavor is to assist emergency departments in using the HRSA grant to move beyond the single decontamination capability mandated by JCAHO toward the establishment of a turnkey decontamination facility outside the emergency room. DHS recommends that this new facility have multiple showers (4+), but the exact number is left to the individual hospitals. The HRSA grant also provides enough funds for 10 ensembles of personal protective equipment.²²⁸ DHS's recommendation is for one person wearing PPE to perform triage and the other nine to assist in the decontamination process—they are to assist in guiding individuals to the showers, in disrobing and in gathering personal items in order to ensure that there is a steady flow of individuals through the showers. The hospital workers would also help monitor the time the victims were in the showers to ensure that they stay long enough to wash off the chemical, but not so long that others are delayed getting into the showers.²²⁹ The recommendation is for those assisting in the decontamination process not to be nurses or physicians, rather, support staff, such as security personnel or medical technicians, since the emergency medical personnel will likely be needed inside the emergency room to treat the victims that have been decontaminated.

The model once again allows us to see the dynamics of mass casualties being processed, since live exercises often do not process large numbers of victims.²³⁰ In some cases, depending on the number of showers available at the hospital, as convergent victims arrive at the hospital and triage takes place, the full capacity of the decontamination facilities is not exploited due to the comparatively

²²⁸ This may not be enough PPE for a hospital, especially more individuals participate in triage as discussed later in the chapter. Hospitals may face an even bigger problem with sizing as emergency responders, since most fire fighters are medium to large fit males, while there is greater variation in the size of hospital personnel. Hospitals will need to evaluate the number and size of PPE necessary for their personnel, rather than realize too late the PPE does not fit their personnel in the midst of an emergency.

²²⁹ The workers may not be able to enforce the minimum/maximum time in the showers, but they could help convince the victims of what is required of them.

slow triage process. If only one nurse or physician is performing triage, as the DHS currently recommends, and takes 30 seconds to one minute per individual, then, as showers are added to the decontamination process, there will be increasingly underused decontamination capacity.²³¹ Figure 5.16 below shows the time necessary to send 350 victims²³² through the decontamination process at a single hospital if 80 percent are worried well and the individuals performing triage mistakenly identify twenty-five percent of worried well as contaminated.

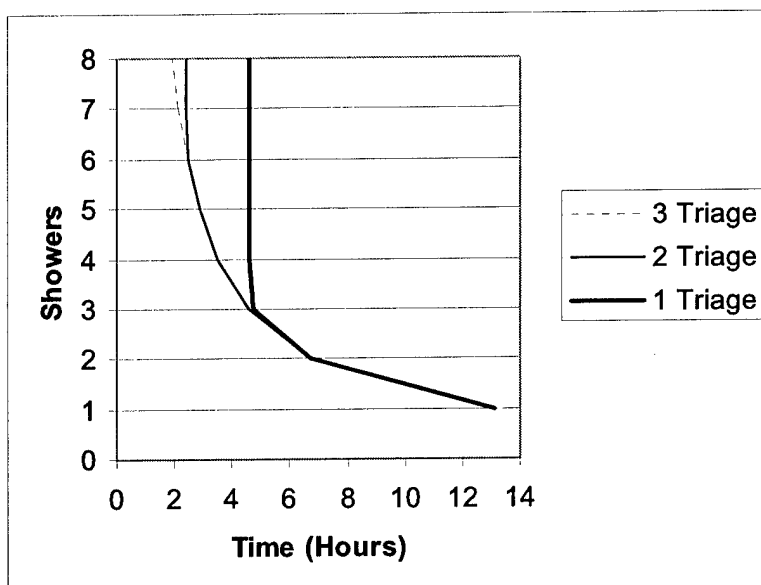


Figure 5.16 Technical Decontamination Time for 350 Victims Based on Number of Showers & Number of Triage Personnel with 25 Percent worried well False Positives

If only one nurse or physician performs triage, as recommended by the current DHS policy and if the hospital has more than three showers, the individual performing triage will not be able to maintain

²³⁰ The exercise data also does not realistically represent the psychological effects of real chemical exposure. In an exercise it may be simple to ask participants only to shower for a set period of time, however in a real event some victims may demand to stay longer in the decontamination process, thus creating a bottleneck. This is a weakness in using the exercise data, as well as relying on averages. However, the simulation using exercise data can still provide a glimpse at some potential problems in the process that might be ignored in not examined.

²³¹ The length of triage is based on the assumption that triage takes between 30 seconds and one minute per patient as described in Chapter Four. The model uses a triangular distribution of $t(.5, .75, 1)$ minutes.

²³² 350 victims is based on 5,000 total victims of which 70 percent are convergent casualties spread equally across ten hospitals. Of the 350 convergent casualties, only 20% or 70 individuals, are contaminated.

the showers at their full occupancy. While the inclusion of worried well false positives in the simulation slows the overall time to perform decontamination, the number of individuals performing triage can also reduce the decontamination time. An additional individual performing triage can help reduce the overall decontamination time by approximately one hour if the hospital has four showers or by two hours if the hospital uses six showers. A third person performing triage offers no benefit until the number of showers is above six (based on 25 percent false positives). The potential for casualties avoided depending on the number of persons performing triage at the hospital can be seen in Table 5.13 below. The table shows six to nine additional casualties avoided when two persons perform triage instead of one, but only one additional single casualty avoided if the triage is raised from two persons to three.

	Parathion	
	High	Low
1 Person Performing Triage	41	23
2 Persons Performing Triage	47	32
3 Persons Performing Triage	48	33

Table 5.13 Casualties Avoided in Response to a Parathion Attack with Convergent Casualties at a Hospital with Either 1, 2, or 3 Persons Performing Triage: 70 Contaminated Casualties, 350 Victims at the Hospital, and 8 Showers.

As the rate of false positives increases there is less benefit of additional personnel performing triage. In Figure 5.17 below, 50 percent of the worried well are false positives. Additionally, the results of conducting no triage (listed as "0 Triage") is included to show the decontamination time if all victims, contaminated and "worried well" (i.e., 100% false positives) were sent through technical decontamination.

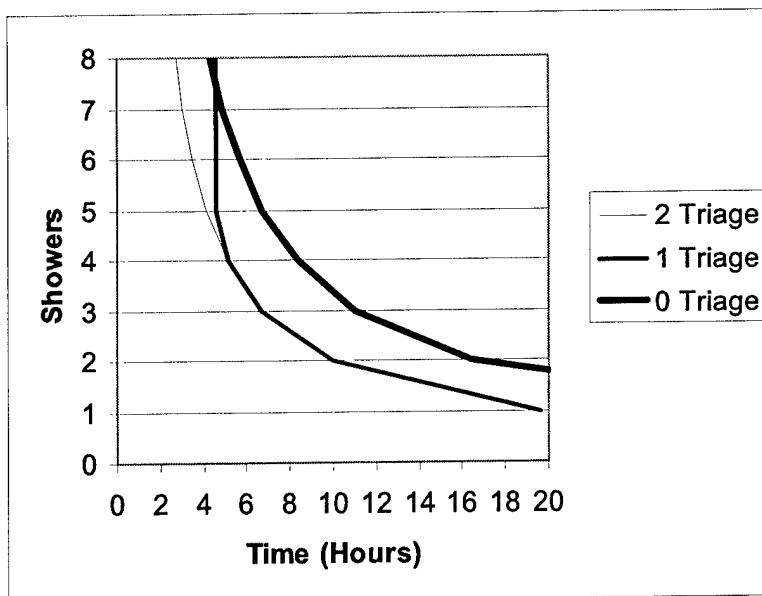


Figure 5.18 Technical Decontamination Time for 350 Victims Based on Number of Showers & Number of Triage Personnel with 50 Percent worried well False Positives

With this less effective triage process, where 50 percent of the worried well are sent along with the contaminated patients to the technical decontamination process, there is no benefit of a third individual providing triage. Since the results of three persons providing triage are virtually the same as with two individuals providing triage, it is not shown in Figure 5.18 above. However, even with less effective triage (i.e., allowing more false positives through decontamination), it is still better to conduct triage with at least two individuals than to provide technical decontamination for all victims with no triage at all—with 2 individuals providing triage the decontamination ends at least 1.5 hours sooner. While a hospital may consider forgoing triage, by providing at least two individuals performing triage, the time to perform decontamination is less regardless whether the hospital uses an number of showers between one and eight. This reduction in time equates to a reduction in casualties. Thus it is better to conduct triage, even when imperfect, than to decontaminate everyone without triage.

Cost of Policy Change

The cost to change from one to multiple individuals performing triage at the hospital is minimal. The hospital has up to 10 PPE ensembles, and the change from nine to eight individuals assisting in the decontamination process would have a minimal effect on the rate of decontamination. These non-

triage personnel would be assisting victims, removing and bagging their clothing, as well as helping them in the showers when necessary. The vast majority of the victims at the hospitals would be ambulatory, so required assistance would be minimal. Each hospital would need to train approximately 10 to 12 individuals to perform triage in order to have two trained individuals available at all times. The cost to the Los Angeles County DHS to train additional personnel could remain the same if the class size at the hospitals was increased (i.e., the cost to DHS to teach a class of 12 students would be the same as to teach two). The individual hospitals need only to ensure that the multiple personnel to perform triage are trained on a regular basis—the low cost videos discussed earlier may be an option for this continuing education.

The number of convergent casualties going to any single hospital after a chemical terrorist event would depend on the proximity of the attack to the hospital and the familiarity of the victims with the hospital. Because of a hospital's proximity and/or its renown, a large number of convergent casualties might surge to its emergency department. In Figure 5.19 below 1,000 of the 3,500 total convergent casualties go to a single hospital with 6 showers. The hospital uses three individuals performing triage and has a 50% rate of false positives during their triage (i.e., 600 people are sent through the showers).

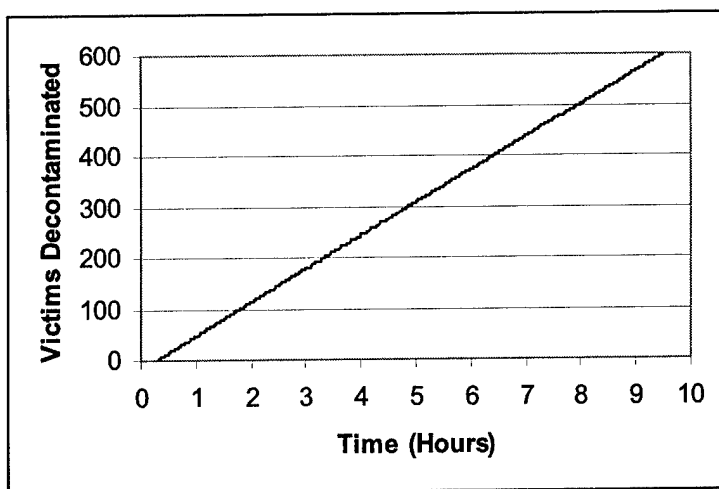


Figure 5.19 Technical Decontamination Time for 600 Victims; Hospital Has 6 Showers, 3 Triage Personnel.

In this scenario, the decontamination process for all 600 victims who were thought to be contaminated would take over nine hours. Obviously, ambulatory victims would not wait this long to get medical help. Many of these patients would leave the hospital to go to other nearby hospitals. The hospital itself could also move some of the ambulatory victims to other hospitals—utilizing buses and vans rather than ambulances. Two additional showers could reduce the total time to seven hours. The logical solution to reduce time is to bring fire department resources to the hospitals after the on-scene decontamination is complete.²³³ If one of the MDUs were brought to the same hospital in the above scenario after finishing its job at the incident site, the hospital could finish its decontamination in just over five hours—see Figure 5.20 below. However, the value of the technical decontamination after five hours may be minimal. Providing earlier gross decontamination and sending victims to other area hospitals may provide a better solution. Most victims would be unwilling to wait this long and would self-evacuate to other medical facilities.

²³³ The mutual aid option discussed previously in this chapter could bring firefighters from departments other than LAFD and LACoFD to the hospital prior to the completion of decontamination at the scene of the incident. However, these non-LAFD/LACoFD firefighters do not have the PPE or training that the two largest departments have received. Thus, if help is needed for technical decontamination, the hospitals would need to wait for LAFD and LACoFD personnel to arrive. The other departments could provide gross decontamination, since it involves minimal contact with the contaminated victims and requires no special equipment.

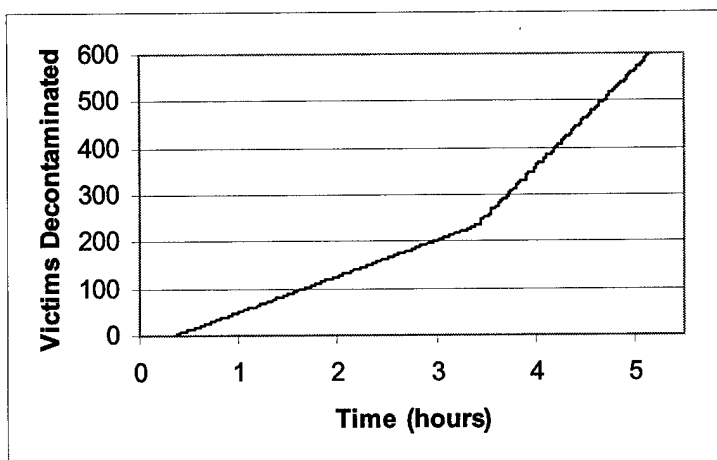


Figure 5.20 Technical Decontamination Time for 600 Victims; Hospital Has 6 Showers, 3 Triage Personnel, and One MDU Arriving at Hospital after Finishing On-Scene Decontamination

Other systems could also be used at the area hospitals after the on-scene decontamination process was complete. However, until the on-scene decontamination process was completed, area hospitals will have to rely on their own decontamination capability.

Conclusion

In terms of on-scene response, the low-cost options of dispersing PPE amongst LACoFD and doing away with the wait time for tents would improve the decontamination process in both LACoFD and LAFD jurisdictions. This could be done at no cost for LAFD and for under \$70,000 for LACoFD. Skills might also be maintained with a training cost of approximately \$20,000. If additional funds were available in the city and county, PPE could be purchased for all operational firefighters to ensure that they had the best sized equipment when they conducted their work. This could be done for an additional \$145,000 for LAFD and \$150,000 for LACoFD at current personnel levels, and for approximately \$70 per new recruit—this may not provide a large impact, but could help ensure these emergency responders could perform their duties if called upon with less impairment.

Hospitals could improve their response capabilities if they take advantage of the HRSA grants (\$30,000 for decontamination facilities upgrade and PPE equipment), which may require them to

provide or seek additional complementary funds. Training will be required for emergency department personnel, including physicians, if hospitals are to provide the necessary services. A low cost/no-cost option to avoid casualties at the hospitals would be to create mutual aid agreements with fire departments other than LAFD and LACoFD who could assist in gross decontamination at hospitals early in the response. In the next chapter various budgetary options will be explored to determine what strategy decision makers might make in order to ensure these improvements in response can be implemented.

Chapter Six: Budget Considerations

"The sorry political reality is that politicians can see no upside in spending their limited resources and time on anti-terrorism."—Jack Weiss, Los Angeles City Councilman ²³⁴

The last domain of the planning framework can be used to answer the question, "What is the right amount of money to spend on this issue?" This is the area with which local decision makers are most familiar—making funding tradeoffs among competing programs. Counter-terrorism in general, and counter-chemical terrorism specifically, must compete for funding at the local level with education, other elements of public safety, transportation issues, medical services, and many other important programs.

From the third domain discussed in Chapter Five, cost-effective options were selected and the corresponding dollar amount for these options was determined. However, it may be that this selected dollar amount, determined by specialists and leaders in the public safety community, when presented to the local level budget decision makers (mayor, county commissioner, city or county councils, etc.), will be found to be too high. These same decision makers, when examining the tradeoffs between countering chemical terrorism and other programs may reduce the amount to a level they prefer, given the relative importance of competing programs.

Since the budget decision ultimately determines the funding amount, the progression from domain one to two to three to four, may in fact also be pushed back in the other direction—from budget to performance to capabilities. With the budget fixed at a certain amount, analysts may have to reexamine the most cost-effective options at that amount. Local decision makers could also conduct some sensitivity analysis by examining the levels of increased prevention and response that could be gained by increasing the budget.

²³⁴ Tina Daunt and Sue Fox, "Anti-Terror Readiness Still Lacking," *Los Angeles Times*, California Metro, Part 2, Page 1, February 23, 2003.

While the desires and needs of a community may be infinite, the budget is not. Hence, local and state governments set priorities to control spending when faced with budget pressures. While counter-terrorism may be deemed important, terrorism is not a daily occurrence in Los Angeles, while street violence, education, and welfare are. The quote by LA City Councilman Jack Weiss at the beginning of this chapter represents the mood of most local decision makers—there is no upside to counter-terrorism spending. While the other three domains are concerned with creating a cost-effective approach based on the goals to respond and prevent the level of terrorism determined through a threat and risk assessment, the local government may not have the budget or the desire to fund at that particular level. Various objectives compete for the limited funds. Thus we can examine in this final domain what might happen at different levels of funding.

Before examining possible budgets and their effects, this chapter will first briefly discuss the budgets in Los Angeles, including the funds currently spent on counter-terrorism.

What and How Does Los Angeles Spend?

Funding for counter-terrorism in Los Angeles has greatly fluctuated over time. Prior to September 11, 2001, what limited funding there was came primarily from the federal government or was provided in preparation for special events, such as the 2000 Democratic National Convention. After the September 11th attacks, funding increased from the city and county, as well as from the federal government. However these funds are mostly one-time grants, and do not address the need for a permanent counter-terrorism readiness posture.

The Los Angeles area has received more federal funding than most metropolitan areas in the United States. At the time of this writing L.A. had received approximately \$29 million in federal grants to be used in its fight against terrorism. This funding was almost exclusively for biological and chemical terrorism—the vast majority (\$24.6 million) from the U.S. Centers for Disease Control and Prevention (CDC), and was granted to the public health department for improvements in the county laboratories for the fight against biological terrorism, as well as for epidemiological early warning and better

communications within the public health sector. The rest of the federal funding was directed toward both chemical and biological terrorism. For example the Health Resource and Service Administration (HRSA) gave the Los Angeles County Department of Health Services (DHS) \$3.6 million for the construction of decontamination facilities in the county's hospitals as well as for PPE and training. Federal grants have come from multiple agencies, each with its own intended use—equipment purchases, training and hospital infrastructure improvements.

In addition to these large federal grants, after the September 11th attacks the Los Angeles local governments have directed more funds towards terrorism than they have received in grants. However, most of the funding that these governments have provided to combat terrorism has been in the form of personnel, training and security measures, rather than response equipment. Between September 11, 2001 and February 2003, the City of Los Angeles has provided approximately \$94 million towards increased security measures (e.g., cameras, fences, motion sensors) at the Los Angeles International Airport (LAX), which has already been targeted by terrorists.²³⁵ The city also has provided \$10 million for increased security at the Port of Los Angeles. During the same time frame the County of Los Angeles has agreed to provide \$6.8 million for a number of counter-terrorism initiatives, including training, decontamination facilities at county hospitals, security personnel, and facility protection measures.²³⁶ These funds include \$1.4 million to increase the staff of the Terrorism Early Warning Group, which has expanded from 2 Sheriff's Deputies to now approximately 25 personnel from multiple agencies.²³⁷

As was indicated in Chapter Five, LAFD spends approximately \$2.16 million each year to train its personnel in terrorism awareness and response.²³⁸ While LACoFD spends less (approximately \$610,000) in annual training, its costs for initial training in preparation for the 2000 DNC was over \$3

²³⁵ Ahmed Ressam, who was arrested in Washington state in late 1999, was on his way to Los Angeles to place a bomb at LAX. See Yoram Schweitzer, "The Bin Laden Principle," The International Policy Institute for Counter-Terrorism, April 4, 2001, Internet: <http://www.ict.org.il/articles/articledet.cfm?articleid=375>.

²³⁶ Daunt and Fox, 2003.

²³⁷ Departments other than LASD have provided personnel to the TEW, so the \$1.4 million does not represent the full cost of the increased personnel.

million. LAPD and LASD also spend time training for counter-terrorism, but not as extensively as the two fire departments. Each of these departments provides personnel that are exclusively dedicated to counter-terrorism. LAPD's Anti-Terrorism Division and the TEW hosted by LASD, are specialized units that draw on annual funds. Likewise, LAFD and LACoFD each provide a few individuals dedicated full-time to counter-terrorism. The total spending in training and counter-terrorism personnel of these two fire departments is approximately \$3 million.

The majority of counter-terrorism funding in Los Angeles comes from local governments, and not from the federal government. Of the approximately \$145 million spent on counter-terrorism in Los Angeles by the end of 2002, \$30 million came from the federal government, and only \$1.35 million of these federal funds have gone towards equipment and training of traditional emergency responders—fire departments, law enforcement and emergency medical services. Equipment and training funds from the federal government represents only .9% of the total counter-terrorism funds expended in Los Angeles. The \$3.6 million from HRSA for the hospitals represents only 2.5% of total counter-terrorism funding.

²³⁸ The counter-terrorism training is not exclusively oriented towards chemical terrorism, but includes conventional, biological and radiological terrorism.

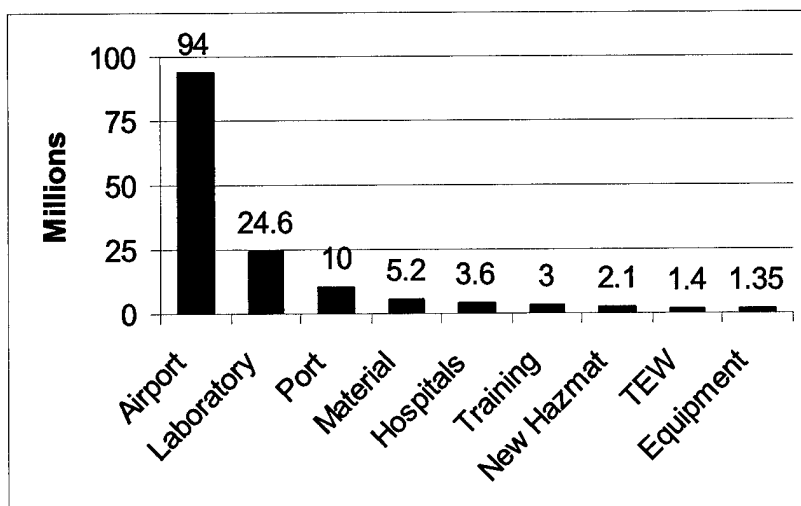


Figure 6.1 Estimated Terrorism Expenditures in Los Angeles (City & County) through 2002

Fixed Cost and Performance

The options for improvement in Chapter Five were suggested as methods to obtain the most benefit for the least cost. The following two budget exercises will seek to explore alternatives to those options in terms of both cost and performance. The suggested low-cost options included purchasing chemical splash suits for LACoFD and placing them on their engines, as well as abandoning the need to use the tents in the current Mass Casualty Mass Decontamination procedures and seek out other alternatives for modesty protection; however, always placing life and injury saving ahead of modesty. Also, the suggested option included adding additional gross decontamination capability as soon as possible. The cost for these options was approximately \$70,000. Chapter Five also suggested spending \$20,000 to create a refresher video on the mass decontamination process, to help ensure the skills gained in training were not quickly lost. At the hospital level, adding triage personnel would also ensure greater decontamination throughput at no marginal cost. Thus, the level of response to a chemical incident could be increased for approximately \$90,000.

Fixed Cost

By fixing the cost of improvements at \$90,000 there are few other alternatives for performance improvements at that level of funds. One option that has been mentioned previously is splitting the current county cache of equipment in two. By having two smaller caches and distributing their location, there is a higher likelihood that one of them would arrive at the scene sooner. The cost to purchase the vehicle, trailer, extra tent (to ensure equal amount of equipment in both caches) and 20 extra chemical splash suits for the additional tent would also be approximately \$90,000. This option would not provide for the training video, nor deviate from present doctrine.²³⁹ Figure 6.2 below shows the performance of the two options against the current baseline.

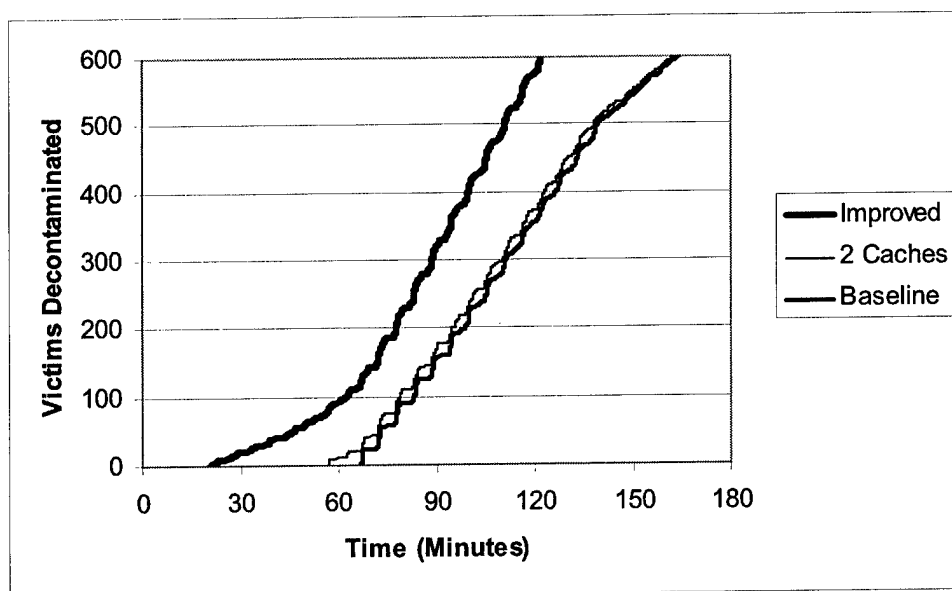


Figure 6.2 Fixed Cost: Comparison of Improved Option, 2 Equipment Caches, and Baseline Using the Full Chemical Terrorism Model²⁴⁰

As can be seen in Figure 6.2 dividing the current cache into two might provided a slight improvement in response time to the incident, but it does not differ greatly from the baseline. The

²³⁹ If the equipment (i.e., splash suits) are located in a cache, rather than distributed to all the fire engines, the fire fighters are forced to wait for the equipment to arrive and are unable to start immediately.

²⁴⁰ The two cache option assumes that with caches split in two would on average reduce the starting time of the decontamination process by ten minutes. This option also assumes that PPE equipment is not distributed to each fire engine, so they must wait for the equipment (PPE & tents) to arrive.

improved option developed in Chapter 5 for the same amount of funds (\$90,000) provides a much greater level of overall improvement in response.

Fixed Performance

By fixing the performance level to the same as the improved option developed in Chapter 5, we can see what other option provides a similar level of performance and determine its cost. An alternative option that has a very similar performance level is to obtain 12 additional Mass Decontamination Units and disperse them throughout Los Angeles, perhaps locating them with the HazMat unit stations, since there is an equal number of them. The performance of both options, as well as the current baseline, are expressed in Figure 6.3 below. The multiple MDUs start slightly later than the improved option, but finish a few minutes ahead. However, the cost of this option would be approximately \$3.5 million—\$2.4 million for the 12 MDUs and approximately \$1.1 million for training of the LACoFD and LAFD firefighters to use the equipment.²⁴¹ In contrast the improved option from Chapter Five provides a faster initial response (beneficial if the incident has less victims) for the cost of \$90,000.

²⁴¹ Currently not all LAFD or LACoFD know how to operate the MDUs in Los Angeles, rather only the firefighters assigned to assist LAX and Ontario Airports are trained on the MDUs.

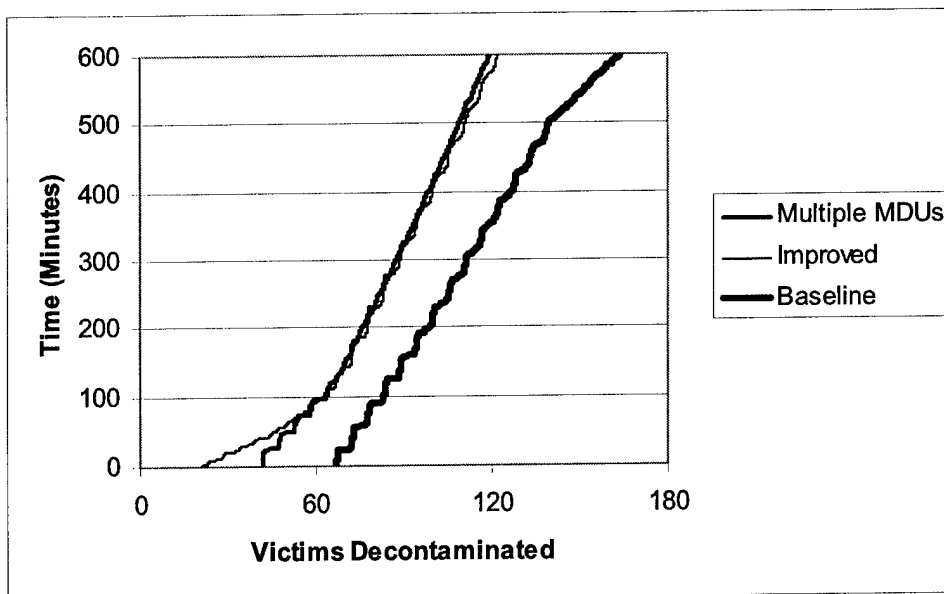


Figure 6.3 Fixed Performance: Comparison of Improved Option, Multiple MDUs, and Baseline Using the Full Chemical Terrorism Model²⁴²

In comparison to the next best option with both a fixed cost and a fixed level of performance, the improved option from Chapter Five is both more effective in terms of response as well as more cost-effective in terms of level of response for least cost. In the future additional options may become available as new equipment is placed on the market, but in the near term the inexpensive improved option of purchasing additional splash suits, dispersing the equipment to the fire engines, forgoing modesty, and increasing gross decontamination provides the most improvement in throughput for the least cost.

Change in Budgets

Decision makers in Los Angeles might consider several types of budgets in the future which they could use towards counter-terrorism, and specifically for addressing the risk of chemical terrorism. For any given program, its budget allocation depends on the total budget available, as well as the priority of the need. It may be useful for decision makers to consider three possible budget levels, and

²⁴² The Multiple MDU option assumes that the response will also use multiple (at least two) engine companies to provide gross decontamination.

determine what benefit could be derived from each. While a given year may only have funds for a small budget increase, the next year's budget may have additional funding available. This dissertation will examine three potential budgets: small, medium, and large. The following are characteristics of each.

Small Budget Increase: Decision makers are either facing a budget constraint due to limited revenues or the priority of other non-terrorism needs require downsizing counter-terrorism programs. A small budget may spend the minimum to maintain current capabilities, and may have to cut back on some budget items.

Medium Budget Increase: A medium budget increase would result when there is a continued desire by decision makers to not only maintain, but to improve current counter-terrorism capabilities and apply increased funding towards that goal. The budget applied in this category would be enough for incremental improvements.

Large Budget Increase: A large budget increase might result in budget surplus, increased federal funding, or a high priority ranking for counter-terrorism initiatives (The funding directly after the September 11th attacks is an example of high spending in a low budget period due to the perceived need of counter-terrorism capabilities.). The large budget option might also include large federal grants, which could help supplement or replace local spending. A large budget increase would be an amount that would provide sufficient funds to support a large increase in capabilities—both in terms of amount and/or quality—rather than merely maintain current capabilities.

Options under each Budget Level

Under each budget level decision makers choose what equipment, training programs, infrastructure and personnel changes that can provide an acceptable level of terrorism preparedness. It may even be a consideration for decision makers to reduce the level of preparedness in order to provide needed funds to some other program. Without providing the decision makers adequate information, they may choose funding options that reduce the level of preparedness or fund less cost-

effective options. If the operational chiefs (e.g. leaders of fire departments, law enforcement, etc.) do not adequately understand what cost-effective options will meet their capability goals, they might present a costly budget request that may or may not necessarily provide the improvements they seek. For the decision makers, who mainly dwell in the fourth domain (budgets), if they are not informed of the best options available, they will make decisions based on their own understanding—most likely not taking into consideration the analysis gained in the other three domains (threat & risk, capabilities, and cost-effective programs). Thus it is essential that the counter-terrorism community provide options based on analysis in each of the four domains to the budgetary decision makers that will provide the biggest “bang for the buck.”

This chapter has described “decision makers” as if there is just one set making funding decisions for Los Angeles as a whole. However, there are at a minimum two sets of decision makers, those of the City of Los Angeles and those of the County, that would need to make the resource allocation decisions. The options and funding amounts have been placed together, but both City and County officials would need to work together to ensure that funding decisions would have the greatest impact for the metropolitan area as a whole. More of the burden in the funding options will fall to the County, but the City too would need to ensure that it was not benefiting without paying for the increased security and improved response.

Table 6.1 below illustrates three collections of operational concepts described in previous chapters that fall under equipment, training, organization and doctrine for each level of budget—small, medium and large. The table also breaks down the cost of the options for both the City and County of Los Angeles.

	Small Budget Increase	Medium Budget Increase	Large Budget Increase
Goal	Utilize no- and low-cost options to increase lives saved and injuries avoided	Address training needs of responders (Building on Small Budget goals)	Improve response through equipment and additional training (Building on Medium Budget goals)
Equipment	-Splash Suits (\$70K)	-Splash Suits (\$70K)	-Personal Splash Suits (\$220K) -Match Federal Grant for Hospitals (\$3.6mil) -Increase MDUs (\$2.4 million)
Training	-Training Video (\$20K)	Training Video Suite (\$80K) -One day training exercises (\$6 million)	Training Video Suite (\$80K) -Two days training (\$12 million) -Live exercises (\$2 million)
Organization	-Decentralize equipment (\$70K*)	-Decentralize equipment (\$70K*)	-Decentralize equipment (\$70K*)
Doctrine	-Forgo modesty (\$0) -Add more hospital Triage capability (\$0) -More gross decon (\$0) -Mutual aid assist hospitals (\$0)	-Forgo modesty (\$0) -Add more hospital Triage capability (\$0) -More gross decon (\$0) -Mutual aid assist hospitals (\$0)	-Forgo modesty (\$0) -Add more hospital Triage capability (\$0) -More gross decon (\$0) -Mutual aid assist hospitals (\$0)
LA City	\$10,000	\$3,040,000	\$8,200,000
LA County	\$80,000	\$ 3,110,000	\$13,600,000
Total	\$90,000	\$6,150,000	\$21,800,000

*The expense is listed previously in the column (chemical splash suits) so it is not added to the total.

Table 6.1 Budget Options and Total Costs for Equipment, Training, Organization & Doctrine

These options were selected because of their estimated returns on the dollars invested in terms of lives saved and injuries avoided. The typical method followed by most decision makers to take advantage of cost-effective options is to create a prioritized list of the most cost-effective options and to work down the list from top to bottom while staying within a certain budget. These options thus represent the best packages within limited budgets. The options in the small budget provide the

highest return on the dollar, while the options in the medium and large budgets have diminishing marginal returns, although they include the high priority options of the small budget.

Small: In a small budget increase environment decision makers will only be able to provide funds for what is deemed necessary to maintain the current or a reduced posture. Decision makers may also need to cut items out of the budget or delay purchases in order to fund even the minimal improvement costs of \$90,000. This would lead to an increased need for cost-effective measures to provide continuity or improvements. High-cost training would not be feasible, but low-cost traditional training would be encouraged.

In Table 6.1 under the Small Budget category, there are limited equipment purchases—only chemical splash suits for LACoFD so that fire department can organizationally decentralize their equipment into the hands of the individual fire companies. Training is maintained at its present level, but decision makers might choose to fund a low-cost video/DVD on decontamination and emergency medical procedures for chemical terrorism response that firefighters and paramedics can review in their own stations. The video would not replace training, but would help ensure that the knowledge they acquire from the limited training they receive is not quickly lost.

The most cost-effective options lie in doctrinal changes, since there are no marginal costs involved. This would include the option to forgo modesty if needed, rather than waiting on tents to arrive. As discussed in Chapter Five, other on-hand options for modesty can be utilized, rather than relying on equipment that takes time to be set up. Gross decontamination should be expanded to use at least two fire engines or more to ensure that victims can have an initial decontamination process and so as not to bottleneck victims waiting for triage and technical decontamination. Non-LAFD/LACoFD fire departments can establish mutual aid agreements with area hospitals to assist in the decontamination process. Lastly, hospitals with multiple showers can improve response by ensuring that at least two individuals provide triage, rather than the standard one person required by current doctrine. Each of these doctrinal changes can be made for a very modest increase in marginal costs, and can provide improvements to response regardless of the budget allocation.

If a chemical terrorist attack takes place similar to the scenario outlined in Chapter 4, the Los Angeles area might save up to 25 - 34 additional lives if the small budget options were previously implemented. If the value for a human life was valued at \$2 million²⁴³, then for a cost of \$90,000, \$50 million - \$68 million could be saved in terms of human lives—a savings of \$555 to \$755 per dollar spent.

Medium: A medium budget increase would allow decision makers to make incremental improvements at low cost, or make smaller purchases of high priced equipment. Decision makers would easily be able to provide maintenance costs of existing equipment and to provide training to personnel. As for any budget amount, cost-effective measures would still be required to ensure a higher level of performance. The main focus of these options, however, is to address training. Without training there is the risk of an ineffective response, thus the medium budget with its emphasis on training addresses this risk.²⁴⁴

In Table 6.1 the same options from the Small Budget are also listed under the Medium Budget. In the medium budget category, training is increased to include one-day hands-on training for LAFD & LACoFD firefighters (including paramedics) on chemical terrorism (this most likely would be combined with biological and radiological terrorism training) at a cost of \$6 million. A robust program of inexpensive tabletop exercise could also be run at the battalion and hospital level to hone the decision skills of potential incident commanders and hospital leaders. Additionally, a full suite of videos/DVDs could be made to refresh training on elements of chemical terrorism—this might include videos on on-scene decontamination, hospital decontamination, triage, and medical services. These videos/DVDs could then be provided to the appropriate response entities.

²⁴³ The September 11th Fund compensated families of that terrorist attack at an average of \$1.8 million per individual who died in the incident. The U.S. Department of Transportation values lives at \$3 million. See, Bill Torpy, "Life: Hard to know what price is right," *The Atlanta Journal Constitution*, March 5, 2004. Reprinted online at http://ase.tufts.edu/gdae/about_us/ackerman_ajc_3-04.html.

²⁴⁴ The U.S. Department of Defense's 2001 Quadrennial Defense Review Report describes the inability to adequately train as an element of "force management risk," which can effect the operational readiness of the force (or in the case of Los Angeles, of the emergency responders). See U.S. Department of Defense, *Quadrennial Defense Review Report*, September 30, 2001, p 57-60.

As stated above, the doctrinal recommendations are the same for this budget option as for the small budget option. For this reason the estimated lives saved would be at least the same, if not marginally more due to the improved training. While this dissertation cannot quantify the exact number of lives saved through improved training, the likelihood of additional lives saved as a result of the medium budget increase is high.

Large: A large budget increase would allow decision makers to provide high-cost equipment, improved security throughout greater areas, and additional training for many or all emergency responders. Less attention might be given to cost-effective options, reflecting the ability to make large improvements in capability through more expensive equipment or training.

In Table 6.1, the large budget category again includes those options that appear in the medium budget and proposes additional funding recommendations. The large budget proposes a matching grant (\$3.6 million) by the county Department of Health Services to the federal HRSA grant to assist area hospitals in building additional outdoor decontamination showers. Many of the area hospitals are reluctant to accept the HRSA grant to build the showers, since the amount of the grant (\$30,000 for each hospital) may not be sufficient to cover the total costs. A matching grant would help ensure that each of the hospitals has expanded turnkey decontamination capabilities. The large budget would purchase splash suits for individuals (i.e., sized to the individual rather than an engine carrying all extra-large suits).

For equipment, Los Angeles might consider purchasing additional mass decontamination units to be spread throughout the county. As noted in Chapter Four, the MDU is the most effective decontamination unit, but requires a large capital expenditure to acquire and to train all LAFD and LACoFD operational personnel in its use.

Los Angeles decision makers might also consider multiple live exercises to provide hands-on training to both responders²⁴⁵ and city leaders. These live exercises are expensive, but an excellent way to train large groups of responders at one time, while establishing a benchmark of current performance levels. The organizational and doctrinal options remain the same under the large budget as under the small and medium budgets. Modeling with more advanced simulation and modeling tools than used in this dissertation is required to approximate the potential for additional lives saved following the changes recommended in the large budget increase option. However, the author feels the increase could be almost half as many as through the small budget increase option.

In all cases, the decision makers can choose low-cost high-impact options to maximize their investment. Under medium and large budgets, decision makers can focus on training, since it helps agencies get the most out of existing equipment. With a large budget, decision makers can focus on high-cost equipment and exercises, which will also increase training expenses. With federal dollars coming in, decision makers might use those funds for equipment, but provide local funding for training and maintenance of the equipment. Decision makers may also be forced, due to budget constraints, to stay in a small budget mode over multiple years, and will need to continually examine what operational concepts provide the most cost-effective results for their limited budgets.

All-Hazards Approach

One approach to ensure that cost-effective options are selected for funding is to take an all-hazards approach. Options that take an all-hazards approach seek to integrate capability improvements that can prepare for or mitigate more than just one type of hazard. Equipment, doctrine, organization, or training options that are exclusively used towards counter chemical terrorism are likely to be less cost-effective and than those that can be applied in many, perhaps more common incidents. For example, improvements in decontamination can help not only chemical terrorism response, but also response to an industrial chemical accident. A responder unit that is only responsible for chemical

²⁴⁵ The live exercise might also provide hands-on intelligence training for the TEW prior to the training exercise as was done in 1999 at the "Westwind" exercise. Thus elements of both prevention and response could be exercised.

terrorism may not be as cost-effective as one that also provides more routine HazMat duties as well. Improvements in physical security deter not only terrorists who wish to perpetrate a chemical attack, but also other types of attacks, as well as criminal activity.

All of the options in the small budget category reflect an all-hazards approach. Splash suits can be used for other hazards, such as industrial accidents or other HazMat incidents. The decontamination training video would also assist in preparing to any hazard that requires decontamination. The organizational and doctrinal changes are also relevant for similar industrial incidents requiring mass casualty decontamination.

Most medium category options are all-hazards as well. Ensuring that each hospital has the capability to decontaminate multiple chemical terrorism casualties would benefit industrial or other contaminating accidents. The more specialized videos, including chemical triage, and emergency medical services for chemicals may be more appropriate for chemical terrorism, but again they can assist in preparing for an industrial chemical accident, depending on the chemicals involved.

The large budget category too has all-hazards benefits. However the increase in the number of mass decontamination units, while able to assist in industrial accidents, would be a large expense for a low probability of use—even though it can be used for other hazards. The live exercises definitely train responders and test their skills, but many of the lessons learned (i.e., in communications, incident command effectiveness, logistics support, etc.) would be relevant to any large-scale incident (e.g., earthquake, large fire, building collapse, or aircraft accident).

Thus the options listed in all three budget options can help increase the level of preparedness not only for chemical terrorism, but also for large scale industrial accidents as well as other natural or man-made incidents.

Conclusion

Decision makers must balance their expenditures on counter-chemical terrorism options against funding for other activities. This also includes balancing expenditures on preparing for chemical terrorism against preparing for all other forms of terrorism. As discussed above, only a small portion of the total funding for terrorism goes towards chemical terrorism. In the on-going budget shortfalls in Los Angeles, made worse by the recent economic downturn, decision makers must choose between options to get the most cost-effective benefit. Options have been laid out in this chapter for decision makers to choose from that would have a large, positive impact on preparedness for a chemical terrorist attack. If decision makers choose not to fund any of these options, then they can still implement the no-cost doctrinal changes that would improve preparedness.

The potential for terrorism in Los Angeles may never abate, and the likelihood of chemical terrorism may continue to grow as terrorists seek low cost methods to capture more media attention. While budgets within Los Angeles may presently be constrained, decision makers may wish to make the most of low-cost options to improve preparedness and channel additional funding in future years when funding constraints may not be as strong. A low-cost hedge now may help deter or better mitigate an attack that would have a tremendous fiscal and psychological cost in the future. However, if decision makers do not follow this resource allocation exercise through all four domains (or a similar process), decision makers might not fund areas that would have as an effective influence on counter-chemical terrorism capabilities as possible.

Chapter Seven: Conclusion

Decision makers must address the question of how to best allocate scarce resources in the face of uncertainty. In order to provide services for their constituents as well as save lives or reduce injury from potential chemical terrorist incidents decision makers must make some difficult decisions. While no system for decision-making is perfect, decision makers can do better than relying on their own educated guesses or following advice based on worse-case scenarios. This dissertation has attempted to assist the decision makers in Los Angeles to gain a better understanding of how to determine low-cost options to help prevent or respond to a chemical terrorist attack, and has done so by following a four step process through risk & planning magnitude, capabilities & performance levels, cost-effective options, and budget levels. Too often decision makers focus on the fourth step (budgets), while operational leaders focus on the second step (capability). What is needed is to look at all four. As threats and risks change, improvements in equipment are made, or budgets change in size, the whole picture needs to be reassessed.

As has been seen in this dissertation, without data it can be difficult to have a firm grasp of the probability of a chemical terrorist incident. While other acts of terrorism occur with seeming regularity, attacks using chemicals are in fact rare. Currently terrorists themselves have started to speak of using chemicals, and evidence has been found to show they are testing the effects of chemicals. Analysts now may see the likelihood of a chemical attack in Los Angeles as low, but the potential damage in terms of lives lost, injuries, psychological damage and financial impact is high if such an attack occurs. While it may be difficult to grasp the full level of the risks, based on the limited data on the threat, it is still possible to develop a risk mitigation plan by working with a planning magnitude. This dissertation adopted a planning magnitude of 1,000 contaminated victims to explore the ability to respond to this size of attack.

With a planning magnitude that represents a "reach" goal while still being plausible, the dissertation examined the current capabilities of Los Angeles to prevent and respond to a chemical terrorist event. Los Angeles already has several programs and equipment specifically for responding to a chemical terrorism, but they had not been modeled to see if they would adequately respond to a chemical incident the size of the planning magnitude. Additionally, the Los Angeles responder community has different equipment and policies in their response plans, which had not been tested to see which was the most cost-effective. It was shown that the current equipment and system of response did not meet their goal in response time.

The examination of cost-effectiveness was the heart of the dissertation. Through use of two simulation models, the dissertation examined low-cost options across doctrine, training, organization and equipment to develop improved options to prevent and/or respond to a chemical terrorist incident. This was done at the planning magnitude of 1,000 contaminated victims, but the dissertation also simulated the response when psychosomatic victims were added to the scene, as well as explore the improved options as lower and higher levels than the 1,000 planning magnitude.

While decision makers may never have sufficient funds to apply to all their community's needs or wants, they can and need to determine an adequate funding amount for each of the competing priorities. The dissertation examined three budget levels—lean, medium, and fat—to see how to best improve response and prevention of chemical terrorism in Los Angeles. The dissertation also used fixed costs and fixed performance levels to test the improved cost-effective options against the next best options.

Recommendations

Based on the dissertation methodology, several options for improved prevention and response were discovered, based on the dissertation's methodology. These options represent low-cost methods to improve the current baseline level of preparedness, which could easily be implemented.

Organization

Los Angeles should stay away from a centralized approach to response, since it may delay response as well as create a potential vulnerability. Instead it should switch evolve a centralized cache approach and put the needed equipment at the fire company level. By decentralizing equipment, the response can start almost immediately with the first arriving fire companies.

Los Angeles should continue to fund the Terrorism Early Warning group. This will help ensure that terrorist incidents can be prevented or deterred, as well as improve the coordination of the response should a terrorist incident occur.

Doctrine

Emergency responders should not wait for equipment, specifically the tents that are part of the current Mass Casualty Mass Decontamination approach. These tents provide limited shelter from the elements and some degree of modesty protection. Rather, emergency responders should change their current policy and start immediately decontaminating the victims based on the instruction of their incident commander. Modesty should be placed below the efforts to save lives or reduce injury. Emergency responders should seek out other methods for modesty protection that take little or no time to set up. This will allow the emergency responders to not only not wait for the tents to arrive, but also not have to spend time setting the tents up while victims wait for their help.

Additional doctrinal options for improved response would be to increase the number of fire engines used in gross decontamination from one to at least two to ensure that process does not bottleneck and force the technical decontamination to operate at less than full capacity. Similarly, if hospitals choose to add showers to their decontamination capability, they should concurrently increase the number of individuals providing triage from one to at least two to ensure that the showers can be utilized at their full capacity.

Training

Training is essential to maintain responders' capabilities to effectively respond to their tasks. However, training is expensive and as such is often reduced to the minimum acceptable level—such as currently spending only two hours a year in classroom-style instruction on terrorism. Other inexpensive options can be used to help maintain the current training levels, such as creating a simple video walking the emergency responders through the elements of a chemical terrorist incident response. These videos can be tailored specifically for the Los Angeles responder community and can be viewed often enough to help ensure the knowledge is maintained. Hands-on training and live and/or tabletop exercises should be conducted when funding is available.

Equipment

The doctrinal and organizational options of starting immediately and decentralizing the equipment cache is only made possible if county decision makers purchase a small quantity of relatively inexpensive personal protection equipment. By ensuring that all fire fighters in LAFD and LACoFD have a chemical splash suits and gloves available on their engines it will allow the improved response initiatives. While this can be accomplished for as little as \$70,000, both of these fire departments may wish to spend more to acquire appropriate sized suits instead of the current "one size fits all" approach. While fire departments are often enamored with large equipment, equipping the responders themselves with low-cost equipment (such as splash suits, gloves, and hoses) is more effective than the purchase of several high-cost devices such as the Mass Decontamination Units—additionally the responders would need the same low-cost equipment in order to staff the MDUs.

All-Hazards Approach

The response community and decision makers should focus on taking an all-hazards approach to their doctrine, organization, training and equipment improvements to mitigate chemical terrorism. If responders use specific equipment or doctrine solely for a chemical terrorist event, they will quickly forget how to effectively use the equipment or follow doctrinal methods. An all-hazards approach helps ensure responders maintain their effective response capability. This approach also

helps ensure that Los Angeles has a higher state of preparedness for multiple risks, and not just chemical terrorism.

Leveraging Future Technologies

While this dissertation has focused on near-term solutions, addressing chemical terrorism will be a long-term problem. Improved technology could greatly assist the emergency response community in Los Angeles in facing a chemical terrorist attack. Improvements in chemical detection and identification could assist the responders in knowing if they are experiencing a chemical attack and what chemicals they are up against. Currently emergency responders need to rely on physical indicators to detect chemicals or on highly trained HazMat operators to provide identification. Hospitals, without early warning, may become contaminated by convergent casualties. Both on-scene and hospital emergency personnel could benefit from passive detection devices (i.e., small devices that are worn or in place that could provide warning when confronting a chemical incident (terrorism or industrial accident). Similarly, hospitals and emergency responders could benefit from small, highly sensitive chemical identifiers—able to detect toxic industrial chemicals and chemical warfare agents.

The Los Angeles area could also use improved decontamination equipment. Equipment that could be more easily transported by vehicle or by air, and more quickly set up, may be of help in dealing with mass decontamination incidents. Similarly, add-ons to existing or future fire apparatus (i.e., one or more boom with multiple shower nozzles) could make each engine a technical decontamination unit.

Los Angeles, while one of the largest metropolitan areas in the United States, with its large emergency responder agencies, is still too small by itself to influence the nation's research and development community. Los Angeles should take part in efforts to band together with other emergency responder agencies across the country to express their technology needs to the federal

government and private industry.²⁴⁶ Los Angeles could also benefit from simulation and modeling tools to conduct further analysis into cost-effective options to respond to chemical and other types of terrorism. The Department of Homeland Security could create simulation and modeling tools that localities, such as Los Angeles, could input their relevant data (e.g., specialized equipment, personnel, maps, response times based on exercise and real events, etc) to continue to explore cost-effective operational concepts. Through further exploration with simulation and modeling, localities could save time and money in identifying promising operational concepts. They could then test these options in tabletop or live exercise.

Transition

Currently Los Angeles, as well as other metropolitan areas, faces a budget shortfall rather than a surplus. This forces decision makers to scrutinize the budgets of the emergency responders as well as other municipal agencies. During this time, the City and County of Los Angeles might chose to follow the options listed under the "Small Budget" from Chapter Six, that is to adopt the no-cost doctrinal and organizational changes, and to purchase the personal protective equipment for \$70,000 and create the training videos for approximately \$20,000. This low-cost option represents only .08 percent of the two fire departments' (LAFD & LACoFD) annual budget, or .6 percent of what Los Angeles has spent on terrorism preparedness. This low-cost option would help ensure that the community best utilizes its current personnel and equipment. When the budget crisis ends, city and county decision makers may wish to choose from either the options from the medium or fat budgets, based on what budget levels they may possess at that time and what risk they believe they face.

The budget allocation process, as outlined in this dissertation, is presently not used in Los Angeles as a formal planning process. In a time of constrained budgets, or even when facing a surplus in funds, Los Angeles would be wise to follow a process of identifying cost-effective options to increase

²⁴⁶ Efforts such as the National Memorial Institute for the Prevention of Terrorism's "Project Responder" is bringing local responders and federal technologists together to create a needs survey and a R&D roadmap for federal

the potential of saving lives and avoiding injuries when facing a chemical terrorist event. Los Angeles could implement this process by working through the four domains (threat, risk and planning magnitude; capability and performance levels; cost-effectiveness; and, budgets) in a series of four workshops. The Los Angeles Terrorism Early Warning Group could host the first meeting to examine the current and future threat and risk of chemical terrorism and to select a planning magnitude that would be a "plausible reach" for responders. TEW members could also participate in the next domain meeting along with special plans and training leaders from the main responder departments to explore the capability and performance levels necessary to mitigate a chemical terrorist incident at the chosen planning magnitude level. Representatives from these previous domain meetings would then work with the participating departments' exercise experts and operational analysts to explore cost-effective options to meet their response goals. The product from the third domain meeting would be a list of the most cost-effective options in responding to chemical terrorism to present in the final meeting—the budget domain meeting. This meeting would have a few representatives from the previous domain meetings present to Los Angeles decision-makers the list of cost-effective options and the process used to create these options. The decision-makers could then, based on their budget resources, chose from the list of cost-effective options.

The budget allocation process is not just limited to chemical terrorism, but could be used for other risks faced by Los Angeles. Additionally, other metropolitan areas could also use this, or a similar process, to determine the appropriate budget level and to find cost-effective methods to prepare for chemical terrorism or other risks. By working through the domains of threat, risk and planning magnitude; capability and performance levels; cost-effectiveness; and budgets; metropolitan areas can be better assured that they are providing the right level of funding to prepare for the risk and thus have the highest possibility to save lives or reduce injuries.

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